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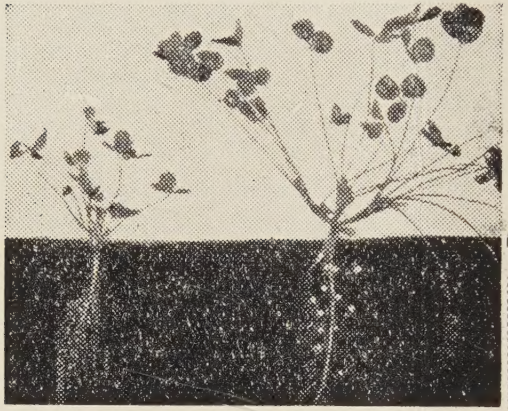

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ARTICLES

ALKALOID POTENTIALITIES OF THE AUSTRALIAN FLORA

By L. J. WEBB

Summary

Over 200 species of Australian flowering plants, from 37 families, were found to contain alkaloidal substances. Alkaloids have so far been confirmed in 26 of these families.

The chemistry and, where known, the pharmacology of about 110 alkaloids isolated during seven years of the Australian phytochemical survey are indicated. To date, about 60 of these alkaloids are known to be new.

Structural work on the alkaloids has made significant contributions to alkaloid chemistry. Due to inadequate pharmacological facilities, assessment of the possible therapeutic value of most of the alkaloids has not yet been made. Nevertheless, a firm basis has been laid for future work.

Results of the survey are relevant to problems of stock poisoning and use of forest products. The taxonomic and ecological significance of the results is also briefly discussed.

INTRODUCTION

Although the first alkaloid from an Australian plant was isolated ninety-two years ago (Zeyer, 1861), many more Australian alkaloids have been characterised over the past seven years than during the whole of the preceding period. This rapid growth of Australian phytochemistry was stimulated by the shortage of strategic plant drugs during the Second World War. *Duboisia*, known to contain hyoscine and atropine since about 1880, was quickly developed as a commercial source of these drugs. This success at once raised the question—are there any more plants like *Duboisia* in Australia? The answer could not be escaped—we did not know. Although our economy was based on pastures, timbers, and their products, we were generally ignorant of the chemical and pharmacological resources of local plants.

So began the Australian Phytochemical Survey in 1945, fostered by the Division of Plant Industry, C.S.I.R.O., and involving the cooperation of several Divisions of C.S.I.R.O., the Universities, and State Departments of Forestry and Agriculture. At the Second Phytochemical Conference held in Melbourne in 1949, Dr. I. Clunies Ross of the Executive Committee, C.S.I.R.O., noted that the Survey had "brought together a larger number of research and educational institutions than had perhaps been achieved by any other cooperative project in Australia."

While chemical facilities expanded rapidly, and the numbers of chemists working on Australian plant products multiplied tenfold by 1947, biological facilities lagged far behind. Considerable information accumulated on the structures and reactions of various new alkaloids and other compounds. Due to the lack of systematic pharmacological testing, little or nothing can be said of their therapeutic promise, except in those cases where the alkaloids are already known in medicine. Lack of coordination and funds has also prevented the liaison of botanist, veterinarian and chemist, necessary for the effective study of plants poisonous to livestock, although a start has been made in Melbourne.

In spite of these shortcomings, the Phytochemical Survey was prosecuted with vigour. A Phytochemical Register was established in C.S.I.R.O. (Melbourne and Brisbane) to record and collate all

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previous and current work on Australian plants. Important botanical collections were made. Alkaloid variability " in the field" introduced significant problems in genetics and ecology. Many new contributions were made to organic chemistry and alkaloid biogenesis. Besides formal chemical knowledge, the Survey will continue to contribute indirectly to physiology and taxonomy, as well as to the solution of economic problems such as poisonous plants and parasite-resistance and irritant principles of timbers. Moreover, there are real grounds for optimism that among the alkaloids and other compounds revealed by the Survey, are valuable therapeutic agents. There are many such precedents in the history of the fine chemical industry, when adequate applied work is eventually done.

The following discussion will be restricted to Australian alkaloids. The original testing, location, and identification of alkaloid sources have been the responsibility of the writer. Detailed chemical work on the alkaloids is separately acknowledged, and was carried out in the Division of Industrial Chemistry, C.S.I.R.O., and the Chemistry Departments of Universities mainly in Australia. The Queensland Herbarium and the Forestry Departments of Queensland and New South Wales were always most helpful. So were numerous private individuals, particularly in North Queensland. To them all, grateful acknowledgment is made.

RESULTS OF ALKALOID SURVEY

The results of the preliminary surveys of the flora of Queensland and New South Wales have been published (Webb, 1949, 1952). Further coverage of genera and families was attained by tests of herbarium specimens (Webb, 1950). Sufficient information is now available to permit the assessment of the alkaloid potentialities of Australian families, and many genera, of flowering plants.

Forty families of native flowering plants (Angiosperms) contain one or more species which gave positive alkaloidal spot-tests:—

Acanthaceae, Aizoaceae, Alangiaceae, Amaryllidaceae, Apocynaceae, Aristolochiaceae, Asclepiadceae, Chenopodiaceae, Compositae, Cunoniaceae, Erythroxylaceae, Euphorbiaceae, Hernandiaceae, Himantandraceae, Labiatae, Lauraceae, Leguminosae, Liliaceae, Lobeliaceae, Loganiaceae, Meliaceae, Menispermaceae, Monimiaceae, Moraceae, Myoporaceae, Nymphaeaceae, Oleaceae, Orchidaceae, Papaveraceae, Phytolaccaceae, Piperaceae, Polygalaceae, Ranunculaceae, Rhamnaceae, Rubiaceae, Rutaceae, Solanaceae, Sterculiaceae, Violaceae, Zygophyllaceae.

Alkaloids have been confirmed in 26 of these families by detailed chemical examination, not yet complete. Sixty families were found to be entirely lacking in alkaloids. Over 200 alkaloidal species were detected during the field surveys, which were mainly confined to Queensland and Northern New South Wales. Inland vegetation was less thoroughly sampled than that nearer the coast, and on *a priori* grounds (botanical affinities) is not so attractive as the latter.

The positive results are discussed under each family, and some of the more important alkaloidal genera are mentioned. Since the taxonomic position of the orders has some significance, the convenient arrangement of Hutchinson (1926, 1934) will be followed.

DICOTYLEDONS

Order Magnoliales

Family Himantandraceae is a small relic family with one genus, confined to north-eastern Australia and the islands immediately to the north. "Magnolia" (*Galbulimima baccata* F. M. Bailey (*Himantandra baccata* Diels.)), a timber tree of North Queensland, contains four alkaloids (and three lignanes). *Galbulimima* sp. (*Himantandra belgraveana* (F. Muell.) Diels.) of New Guinea has

two alkaloids. Their chemistry is being studied by Hughes and Ritchie (personal communication). Overseas Magnoliaceae yield bisbenzylisoquinolines which are cardiac depressants (Henry, 1949).

Order Anonales

Family Anonaceae: Although this tropical and subtropical family is fairly well represented in Queensland, its members have given only negative or slight indications of the presence of alkaloids. The tropical species of New Guinea may be more promising. The closely related Eupomatiaceae are negative. Elsewhere, Anonaceae has yielded alkaloids of the active aporphine group (Henry, 1949).

Order Laurales

The families Lauraceae, Monimiaceae and Hernandiaceae have Australian representatives (mainly tropical) with numerous alkaloids.

In Lauraceae, *Cryptocarya* has about a dozen alkaloidal native species. "Poison Walnut" (*Cryptocarya pleurosperma* Wh. and Fr.) contains cryptopleurine, which rapidly attracted the attention of pharmacologists due to its untoward effects on anyone handling the bark or sapwood. It caused severe blistering (similar to mustard gas), headache and dizziness among collectors (Webb, 1948*a*, 1948*b*). It was shown to be one of the most toxic alkaloids known, and its vesicant action is unique among alkaloids (Shaw, 1947, de la Lande, 1948). Further pharmacological tests have indicated that, in small concentrations, cryptopleurine stimulates nerve regeneration and may have important clinical possibilities (Hoffmann, personal communication). The C-mitotic activity of cryptopleurine was demonstrated by Barnard (1949) who noted that it seemed an excellent substitute for colchicine in cytology. Chemically, the alkaloid is extremely complex, and little progress has so far been made with structural work (Price, personal communication). Investigations have not been assisted by the elaborate precautions (protective clothing etc.) necessary for laboratory workers. Cryptopleurine undoubtedly furnishes one of the most challenging problems among Australian plant products.

C. bowiei Druce (*C. australis* Benth.) is of interest because it contains an alkaloid related to dehydrolaudanosoline, obtained by oxidation of one of the Opium Poppy alkaloids. This is the first record of the natural occurrence of a derivative of dibenzopyrrocoline. Bark from North Queensland gave a water-soluble alkaloid cryptaustoline $C_{20}H_{24}O_4NI$, whereas bark collected in Southern Queensland gave a different alkaloid cryptowoline $C_{19}H_{20}O_4NI$ (Ewing *et al.*, 1952, 1953). Similar variation of alkaloid type with locality has been encountered several times during the survey (e.g., *Daphnandra micrantha* Benth.).

Cassytha pomiformis Nees. of Western Australia yielded 0.4 per cent. crude alkaloid (White, personal communication). The Queensland species of "Dodder" also contain alkaloids. Related species are reputed abortifacient and to contain larotetanine (Webb, 1948).

The family Monimiaceae has several native genera rich in alkaloids. The five Australian species of *Daphnandra* ("Sassafras," "Socket Wood" etc.) contain various bisbenzylisoquinolines. The alkaloid content of *D. micrantha* bark was shown to vary considerably with locality, and provides an interesting ecological and genetical problem (Henry, 1949; Bick and Todd, 1948, 1950; Bick *et al.*, 1949; Bick *et al.*, 1953). Suggested structures for one of the alkaloids (daphnandrine) are shown (Fig. 1). *Doryphora* and *Atherosperma* also contain alkaloids. "Southern Sassafras" (*A moschatum* Labill.) has the distinction of being the first Australian alkaloidal plant examined. Its bark contains about 2 per cent. alkaloids, mainly atherospermine $C_{37}H_{46}O_6N_2$. Four other bases are present, two of them being yellow. The leaves have about 0.25 per cent. of a mixture of three alkaloids, without atherospermine (Crow, personal communication). Atherosperm-

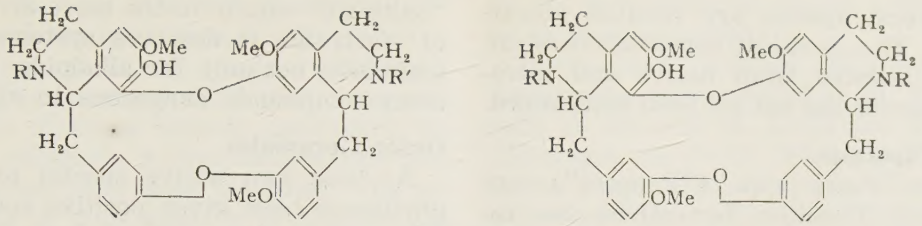


Figure 1.
Suggested structures for daphnandrine (a bisbenzylisoquinoline). These are alternate formulae in which R = H and R^1 = Me.

ine, like berbamine, may prove to be useful in preparing curariform agents (Bick, personal communication).

The small tropical family Hernandiaceae contains the local alkaloidal genera *Hernandia, Gyrocarpus* and *Valvanthera.* Phaeanthine and the quaternary base d-magnocurarine were identified in "Propellor Tree" (*Gyrocarpus americanus* Jacq.) (McKenzie and Price, personal communication). The latter alkaloid belongs to a group of drugs which are ganglionic blocking agents, and may be useful in treatment of certain heart disorders (de la Lande, personal communication). *H. bivalvis* Benth. and *H. peltata* Meissn. yielded new alkaloids, one of them an isoquinoline (Lahey, personal communication). *Valvanthera* has not yet been examined in detail.

Order Ranales

This large order is comparatively rare in the tropics and Southern Hemisphere. Elsewhere, Ranunculaceae contains berberine and related alkaloids, while Nymphaeaceae yields toxic alkaloids of undetermined constitution (Henry, 1949). Australian representatives are not promising, although *Nelumbo nucifera* Gaertn. (*N. speciosum* Willd.) and *Clematis* spp. are worthy of further examination.

Order Berberidales

The mainly tropical family Menispermaceae is fairly well represented in Northern Australia. With the possible exception of *Tinospora,* all (about ten) genera of these vines contain appreciable alkaloid in the bark of the roots. Elsewhere the family is the chief source of the bisbenzylisoquinoline group of alkaloids (see structural formula Fig. 1), many of which are used as crude drugs in Eastern Asia, and whose pharmacology is of great interest. The Australian *Pleogyne cunninghamii* Miers. contains *l*-bebeerine (*l-curine*) and *d*-isochondrodendrine (Anet *et. al.,* 1950), while isocorydine has been isolated as the methiodide from *Legnephora moorei* F. Muell. popularly called "Native Grapes" (Hughes *et al.,* 1953). Oddly enough, this complex alkaloid also occurs in the native *Zanthoxylum brachyacanthum* F. Muell. belonging to Rutales, and only distantly related to Berberidales. The similar occurrence of berberine in these and other taxonomically distant orders has been held to support the hypothesis of parallel evolution. Chemical work is continuing on other members of local Menispermaceae. Of possible therapeutic value is their curariform activity. Japanese species of *Stephania* are held to be of promise in the chemotherapy of tuberculosis (Anon, 1950). A few limited tests with the local *S. hernandiifolia* Walp. ("Tape Vine") showed the crude alkaloid to have no effect on *Myco. tuberculosis,* but it inhibited *Myco. phlei* and *Staph. aureus* at a concentration of about 1/1600. (Atkinson, personal communication).

Order Aristolochiales

The roots of local Aristolochias ("Dutchman's Pipes") contain alkaloids,

and several species are reputed abortifacient. The chemical constitution of alkaloids isolated from native and introduced species has not yet been determined.

Order Piperales

Native *Piper* spp. ("Peppers") are alkaloidal. Pyridine derivatives are recorded in overseas species. Piperine has insecticidal properties.

Order Rhoeadales

This order is mainly characteristic of north temperate regions and is poorly represented in Australia. *Papaver aculeatum* Thunb. (*P. horridum* DC.) ("Native Poppy") contains alkaloids, but has not been investigated recently. Previous work suggested that morphine was absent (Webb, 1948).

Order Violales

A native species of *Hybanthus* (Violaceae) gave positive alkaloidal tests, but it is an insignificant herb and an adequate sample was not collected for confirmation. This order is not recorded in the alkaloid literature.

Order Polygalales

Xanthophyllum octandrum (F. Muell.) Domin (*X. macintyrii* F. Muell.) (Polygalaceae), a large timber tree known as "Sovereign Wood," may contain a water-soluble alkaloid. The order is not recorded elsewhere as alkaloidal.

Order Caryophyllales

Several local species of Aizoaceae are probably alkaloidal. Minor alkaloids have been reported in overseas species.

Order Chenopodiales

Certain native species of Chenopodiaceae and Phytolaccaceae have given positive tests for alkaloidal substances, not yet confirmed as alkaloids. They are mostly inhabitants of drier inland regions, and some are reputedly poisonous to livestock (e.g. *Chenopodium, Kochia, Salsola, Threlkeldia*). Chenopodiaceae is known elsewhere to yield toxic alkaloids, and in view of the importance of the "Saltbush" family in the more arid areas of Australia, it deserves systematic examination not only for alkaloids, but for other compounds dangerous to stock.

Order Geraniales

At least two native species of Zygophyllaceae have given positive spot-tests, but alkaloids have not yet been isolated.

Order Cucurbitales

Although mentioned in the alkaloid literature, these groups doubtfully contain alkaloidal representatives.

Order Tiliales

Several species of Sterculiaceae contain small amounts of alkaloidal material, particularly in the seeds.

Order Malpighiales

As found elswhere (cocaine etc.), several Australian species of *Erythroxylon* (Erythroxylaceae) contain alkaloids. *E. australe* F. Muell. yielded 0.6 per cent. alkaloids which were not identified. *E. ecarinatum* Hochr. ("Brown Plum") gave only a trace of alkaloids (Mortimer, personal communication).

Order Euphorbiales

Several native species of Euphorbiaceae have given anomalous positive tests for alkaloids. The seeds of some may be worthy of detailed study (cf. alkaloid in Castor Oil seeds).

Order Cunoniales

Leaves of the sprawling shrub *Aphanopetalum resinosum* Endl. (Cunoniaceae) contain alkaloids not yet characterised. It is another group not recorded in the usual alkaloid literature.

Order Leguminosae

This widely distributed order, whose three families are extensively developed in Australia, contains many alkaloidal species. Out of 194 species tested, mainly from Queensland, 34 were positive. This number will be increased when genera and species restricted to other States are systematically extracted. The order is well-known as a source of several import-

ant drugs, and contains numerous poisonous plants of economic importance.

Various species of *Acacia* ("Wattles") have given positive alkaloidal tests, and in some of these already examined, the simple alkaloids β-phenylethylamine and tryptamine have been identified. The occurrence of these bases is of considerable taxonomic and biogenetic interest (Briggs, 1947).

Crotalaria ("Rattlepods") has many alkaloidal and poisonous species. They are now being systematically examined (Price *et al.*, personal communication). Similar alkaloids (pyrrolizidines) occur in *Crotalaria, Senecio* (Compositae) and *Heliotropium* (Boraginaceae), and cause liver necrosis in livestock (Henry, 1949). *C. retusa* L. from the Kimberleys contains two other alkaloids in addition to monocrotaline, and is held responsible for Kimberley horse disease.

The seeds of *Erythrina* spp. ("Coral Trees") may contain alkaloids with curariform activity (cf. Webb, 1948).

Seeds of "Cooktown Ironwood" (*Erythrophloeum chlorostachys* (F. Muell.) Bail.) contain alkaloids closely resembling the toxic erythrophleine. The latter is derived from the notorious "sassy bark" used as an arrow and ordeal poison in Africa, and possesses local anaesthetic and cardioactive properties (Webb, 1948). No alkaloids could be extracted by ether or alcohol from bark of "Cooktown Ironwood" recently collected near Mareeba, North Queensland (Clare and White, personal communication).

Gastrolobium and *Oxylobium* ("Heartleaf Poison Bush," "York Road Poison Bush" etc.) are well known stock poisons in Western Australia. They reputedly contain toxic unstable alkaloids (Henry, 1949), but recent chemical work has failed to confirm this. Thus, a highly toxic water-soluble concentrate was prepared from the seeds and seed-pods of *Oxylobium graniticum* S. Moore (Bottomley, 1950), but the basic fraction was non-toxic (White, personal communication). The concentrate was later tested for amine oxides with negative results (Price, personal communication).

Hovea spp. contain alkaloids, and d-sparteine was indentified in *H. longifolia* R. Br. and *H. acutifolia* A. Cunn. (Morrison and Neill, 1949). This belongs to the Lupin alkaloid group.. The examination of *Hovea* stimulated further local synthetic work by Anet *et al.* (1950*a*).

Petalostylis labicheoides R. Br. yielded tetrahydroharman, not previously obtained from natural sources, and of interest in connection with alkaloid biogenesis (Badger and Beecham, 1951). The harman alkaloids have possible therapeutic uses as protozooicidal agents, coronary dilators and ecbolics. and in certain nervous diseases (Henry, 1949).

There are many other examples of alkaloidal species among native legumes, but the alkaloids have not yet been characterised. The active principles of some poisonous species are apparently not alkaloids e.g. *Indigofera enneaphylla* L., responsible for Birdville Disease in horses.

Order Urticales

A plant doubtfully indentified as *Ficus casearia*? (Moraceae) has repeatedly given positive alkaloidal tests. The group, although not generally regarded as a source of alkaloids, may be worthy of further attention.

Order Celastrales

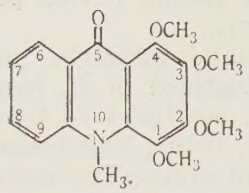
The results of alkaloid spot-tests on several species of Celastraceae suggest that these species should be examined in more detail. Alkaloids have been recorded recently in overseas members of the family.

Order Rhamnales

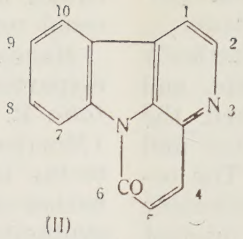
The remarks under Celastrales apply to several local species of Rhamnaceae and Elaeagnaceae, although the latter families are not supposed important sources of alkaloids.

Order Rutales

On the other hand, there can be no doubt of the importance of native mem-

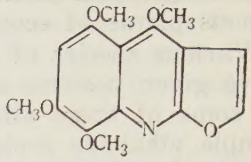


Melicopicine
(an acridone).

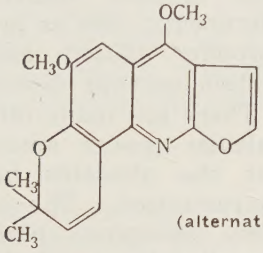


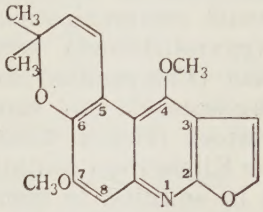
(II)

Canthin-6-one
(a canthinone).



Acronycidine
(a furoquinoline).





Acronicline
(alternative formulae. A furoquinoline plus dimethylchromene ring).

Figure 2.
Showing structures of some alkaloids isolated from native members of the family Rutaceae.

bers of the family Rutaceae as alkaloid sources. About 20 per cent. of species tested contained alkaloids, which are of diverse types. The following classes of alkaloids have been identified in native species—acridones, canthinones, furoquinolines and benzylisoquinolines.

The acridone alkaloids occur in certain native species of *Acronychia, Evodia* and *Melicope*. These are small rain-forest trees. Structurally, these alkaloids are related to acridine, and represent the first record of this ring system in nature. The structural formula of melicopicine, one of about ten alkaloids of this type isolated, is shown in Fig. 2 (Price, 1952).

Canthinone alkaloids were obtained from "Black Teak" (*Pentaceras australis* Benth.). The structure of canthin-6-one is shown (Fig. 2), (Haynes *et al.*, 1952; Nelson and Price, 1952). Here again is a new ring system, from some points of view more remarkable than the acridones. One of the three alkaloids is even more interesting in that it contains sulphur, i.e., the very unusual $-SCH_3$ group instead of $-OCH_3$. In this respect, the substance is unique among plant alkaloids.

Known furoquinolines have been isolated, such as kokusaginine and skimmianine. Several new representatives of the group have also been found e.g. acronycidine (structure shown in Fig. 2), in *Acronychia Baueri* Schott. (*Bauerella australiana* Borai.) and *Melicope fareana* Engl. (Lahey *et al.*, 1950) and flindersiamine in *Flindersia* (Anet *et al.*, 1952). Two new complex pyranofuroquinolines were discovered—acronidine (see Fig. 2), in *A. Baueri*, and medicosmine in *Medicosma cunninghamii* Hook (Lamberton, 1953).

The important genus of commercial timber trees (*Flindersia*), which yields Maple, Ash, Silkwood, etc., has an array of interesting compounds, including two furoquinolines, and a new alkaloid of novel constitution from wood of Crow's

Ash or Native Teak (*Flindersia australis* R. Br.) (Hughes, personal communication).

"Thorny Yellow Wood" (*Zanthoxylum brachyacanthum* F. Muell., *Z. veneficum* Bail.) contains chelerythrine, *l*-*a*-canadine, *β*-homochelidonine, and isocorydine (Cannon *et al.*, 1953). This is a physiologically active group deserving further study. The recently discovered alkaloid, canthin-6-one, was isolated from *Z. suberosum* C. T. White (Ibid).

Other native Rutaceae which contain alkaloids belong to *Lunasia, Micromelum,* and possibly *Boronia.* Chemical work in progress gives good promise that further new types of alkaloids will be revealed in the family.

The only alkaloid so far examined at all thoroughly for pharmacological activity is acronycidine. It is relatively non-toxic to mice, and resembles skimmianine in its two most marked properties—effect on voluntary muscle and causing cessation of heart beat (Lahey *et al.*, 1950). The acridones are weakly basic, so that aqueous solutions of their salts are too acid for normal pharmacological procedures.

Order Meliales

Several native species of Meliaceae gave doubtfully positive tests and are probably of no significance as alkaloid sources.

Order Umbelliflorae

Alangium (Alangiaceae), popularly called "Musk Wood," contains toxic alkaloids which have not been purified despite attempts by various chemists. Samples of Umbelliferae from the warmer parts of Australia were negative, but the more numerous species distributed in the southern States have not been tested. Some of them may be found to yield alkaloids (cf. coniine).

Order Loganiales

The four native species of *Strychnos* (Loganiaceae) contain alkaloids. Samples of *S. lucida* R. Br. seeds from Chillagoe, North Queensland, yielded approximately 0.3 per cent. strychnine, 1.5-2.4 per cent. brucine, and two other alkaloid fractions (Shaw and de la Lande, 1948). Other seed samples from the Kimberleys in Western Australia contained about 0.8 per cent. strychnine and 1.5 per cent. brucine (Watson, 1940). Watson's analysis was confirmed by the B.P. method, but the crude alkaloid isolated from the seeds decomposed on drying at 100°C. (Bottomley and White, personal communication). From fruits of *S. lucida* were isolated loganin (1.1 per cent.) which appears to be confined to the pulp, strychnine (0.1 per cent.), and an unresolved glassy alkaloidal mixture (0.5 per cent.). "Lucidine — S" could not be separated (Anet *et al.*, 1953). *S. psilosperma* F. Muell. has the two new alkaloids strychnospermine (Anet *et al.*, 1950*b*), and spermostrychnine (Anet *et al.*, 1953) closely related to strychnine, but which do not occur in the closely allied *S. arborea* A. W. Hill (Hughes and Ritchie, personal communication). *S. bancroftiana* Bail., a vine, also contains alkaloids.

One or two other native species of Loganiaceae (e.g. *Fagraea muelleri* Benth.) would be worthy of detailed examination. The strychnine content of *Strychnos lucida,* as the shrubs naturally occur, is insufficiently high for commercial exploitation. This, and various other examples where valuable alkaloids have been located in native plants, raises the need for selection and cultivation.

The family Oleaceae has several indigenous species (e.g. *Jasminum*) giving positive alkaloidal tests, which deserve confirmation.

Order Apocynales

The tribes Carissiae and Plumerieae of Apocynaceae are particularly rich local sources of alkaloids. *Alstonia constricta* F. Muell., *A. spectabilis* R. Br. (*A. somersetensis* Bail.), *A. scholaris* R. Br., *A. muelleriana* Domin. (*A. villosa* Blume), *A. actinophylla* (A. Cunn.) K. Sch. (*A. verticillosa* F. Muell.), ("Milky Pine,"

"Bitter Bark" etc.) contain numerous alkaloids of undetermined constitutions, which render them attractive to organic chemists. Their pharmacology is also of considerable interest, although their anti-malarial reputation has not generally been confirmed (Henry, 1949; Wakim and Chen, 1947).

Ervatamia spp. ("Iodine Bush") (*Tabernaemontana* spp.) contain alkaloids. Attempts to elucidate the structure of a crystalline alkaloid obtained in low yield from *E. angustisepala* (Benth.) Domin. have so far been unsuccessful (Hughes and Ritchie, personal communication).

A new species of *Kopsia* from North Queensland has yielded two alkaloids (Crow, personal communication), neither of them the same as that isolated from the Indian *K. fruticosa* A.DC. by Battacharya *et al.* (1949).

Lochnera rosea Reichb. (*Vinca rosea* L.), "Pink Periwinkle," widely reputed to have anti-diabetic properties (Webb, 1948), contains alkaloids not yet characterised.

Melodinus spp. contain alkaloids not yet investigated in detail.

Ochrosia spp. also contain alkaloids not yet characterised.

The family Asclepiadaceae has certain native species of *Marsdenia* and *Tylophora* in which alkaloids have been detected. They have not yet been fully examined.

The order Apocynales is known elsewhere to yield compounds of great pharmacological interest and clinical value.

Order Rubiales

The family Rubiaceae is mostly tropical in distribution, and is a source of important drugs such as quinine and emetine. The Australian representatives of this family have been singularly disappointing from the alkaloid point of view. Some species of *Antirhea* and *Randia* may contain unstable alkaloids.

"Turkey Bush" (*Hodgkinsonia frutescens* C.T.W.) yielded an alkaloid isomeric with calycanthine, which is unstable to acids and gives an indole derivative (Hughes and Ritchie, personal communication). Calycanthine is obtained from *Calycanthus* (Rosales). It produces symptoms similar to those due to strychnine, and acts as a stimulant to the spinal cord and as a cardiac depressant (Henry, 1949). *H. ovatiflora* F. Muell. may also contain alkaloid.

Plectronia attenuata (R. Br.) Gardn. and *P. latifolia* (F. Muell.) Black, from Western Australia contained very faint traces of crude alkaloids (White, personal communication).

Order Asterales

The large advanced family Compositae has yielded only a slender harvest of alkaloidal species e.g. belonging to *Brachycome, Centipeda, Gnaphalium, Senecio* and *Vernonia.* In view of the erratic distribution of alkaloids in this family, probably all species should be systematically tested.

Traces of alkaloids were confirmed in *Gnaphalium luteo-album* L. and G. *purpureum* L. The alkaloids of *Senecio* (cf. *Crotalaria, Heliotropium*) are of interest as possible stock poisons, causing liver necrosis. The examination of local *Senecio* spp. has not yet given any results.

Order Campanales

Various native species of *Isotoma, Lobelia* and *Pratia* (Lobeliaceae), which are herbs with a milky sap, contain alkaloids. So far, from *I. petraea* F. Muell., one of the plants used by the aborigines as a "pituri" (chewed as a narcotic), a crystalline alkaloidal fraction has been obtained but not yet identified (Rodda, personal communication). The related *I. longiflora* Presl. is said to contain a lobeline-like alkaloid whose pharmacology resembles that of nicotine (Henry, 1949).

Order Boraginales

Heliotropium europaeum L. ("Heliotrope") has been shown to contain heliotrine and lasiocarpine (Trautner and Neufeld, 1949; Drummond, 1951). This plant has been implicated in cases of toxaemic jaundice in sheep in southern Australia. The characteristic liver damage of Heliotrope poisoning is caused by one of the alkaloids (Bull, Dick and McKenzie, personal communication). Native *Heliotropium* spp. generally occur in drier inland areas and are relatively inaccessible, so no complete alkaloid survey has been made of them. The naturalised *H. amplexicaule* Vahl. gave positive tests. Other native Boraginaceae are worthy of more intensive examination in view of their possible economic importance as stock poisons.

Order Solanales

The family Solanaceae is rich in alkaloid-bearing plants. Several *Anthocercis* spp. tested gave positive results. Small amounts (up to 0.05 per cent.) of crude high boiling point alkaloids were obtained from *A. intricata* F. Muell., *A. littorea* Labill., and *A. odgersii* F. Muell. but these have not been satisfactorily purified or characterised (Bottomley and White, personal communication). Reinvestigation of the alkaloids using modern chromatographic methods should be worthwhile.

Datura leichhardtii F. Muell. is the only native species of Thorn Apple. The leaves contained 0.33 per cent. of hyoscyamine, *nor* hyoscyamine and possibly traces of a third base. The roots (0.31 per cent.) and stem (0.07 per cent.) contained hyoscyamine and *nor* hyoscyamine only (Mortimer, personal communication). Overseas *Datura* spp. are commercial drug sources, and several of these species have become naturalized in Australia.

Duboisia myoporoides R. Br. and *D. leichhardtii* F. Muell. are famous because they are now among the principal world sources of the important drugs hyoscine and atropine. Although the mydriatic activity of extracts from *D. myoporoides* ("Corkwood") had been appreciated much earlier by Bancroft (Webb, 1948), the systematic investigation of these species, and their commercial development, did not occur until the Second World War. This utilization was the first direct result of the "Drug Plants Survey," conducted jointly by C.S.I.R.O. and Sydney and Melbourne Universities, which grew into the present Phytochemical Survey. Since the alkaloids hyoscine and hyoscyamine occurred in relatively high percentages, and their use was already known, the problem of their adequate pharmacological and clinical testing did not rise. As mentioned previously, this is a formidable problem for the many new alkaloids discovered during the Survey. *D. hopwoodii* F. Muell. chewed as "pituri" by the aborigines (cf. *Isotoma petraea, Nicotiana* spp.) contains nicotine and *nor*-nicotine. The history of the Duboisias, with full references to chemical work upon them, is contained in a recent review by Barnard (1952). Tigloidine, another of the *Duboisia* alkaloids, has therapeutic possibilities (Trautner and Noack, 1951).

Isandra bancroftii F. Muell. gave 0.05 per cent. crude alkaloid (White, personal communication).

The important genus *Nicotiana* (Tobaccos) has many species indigenous to Australia. Some of these have been investigated, mainly by overseas workers, and each species falls into one of four groups depending on the predominant alkaloid—whether nicotine, *nor* nicotine, a mixture of these, or anabasine (Webb, 1948; Henry, 1949). These alkaloids have well-known insecticidal properties.

Solanum spp. are common, both native and naturalized, in Australia. They are rich in alkaloids of the solanine group. These are glycosidic, with a steroid structure, and are toxic. The native *S. laciniatum* Ait., (*S. aviculare* Forst.), known as "Kangaroo Apple," contains solasonine (Bell and Briggs, 1942). The introduced *S. auriculatum* Ait. ("Wild Tobacco"), which is an aggresive weed on the Ath-

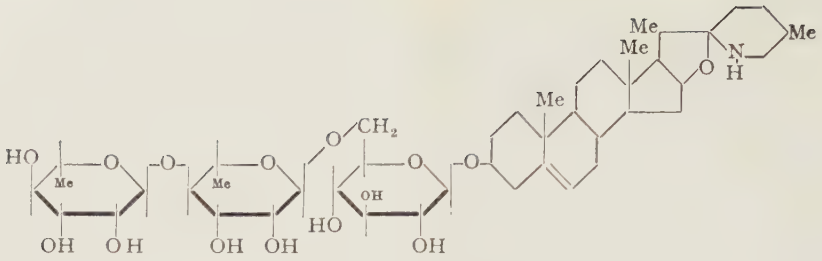


Figure 3.
Structural formulae—solamargine.

erton Tableland North Queensland and other cleared rain forest areas, originally gave solauricine (Bell *et al.*, 1942; Briggs and Carroll, 1942). Later experiments gave only solasonine. Extraction by hot methanol of the fresh berries also gave solasodamine, which is a new tetrasaccharide derivative of solasodine. The structural formula of the related solamargine is given in Fig. 3, (Briggs, personal communication). Solasonine, by acid hydrolysis, yields solasodine, which is the nitrogen analogue of diosgenin (Briggs *et al.*, 1950). In one experiment, N-nitrososolasodine was converted in extremely small yield to diosgenin, the identification of which depended only on mixed M.P. and the general crystal properties. The main yield was an isomer of diosgenin (Briggs and O'Shea, 1952). Further experiments gave only the diosgenin isomer. This can be obtained directly in one stage from solasodine, sodium nitrite and hydrochloric acid. This isomer may be used as a source of cortisone, since the isomerism is only in the side chain which is ultimately oxidised off. The ease of isolation of the isomer, in comparison with that of diosgenin, is an advantage (Briggs, personal communication). Thus solasonine could be used as a commercial source of cortisone, which has recently attained world-wide prominence in the treatment of rheumatoid arthritis and allied diseases. Our *Solanum* spp., generally regarded as poisonous weeds, may therefore be of great potential importance in clinical medicine.

Two further *Solanum* alkaloids, β-dihydrosolasodine and tetrahydrosolasodine, are related chemically and pharmacologically (anti-cardioacceleration effect) to the *Veratrum* alkaloids. In potency they are weaker than veratramine, but stronger than jervine (Krayer and Briggs, 1950). The *Veratrum* alkaloids have received attention as insecticides, and, in view of their hypotensive action, medical interest has recently revived in their clinical use (Henry, 1949; Glen *et al.*, 1952).

S. lasiophyllum Dun. fruits yielded 1.3-4.4 per cent. crude solanine-like alkaloid (White, personal communication).

Crystalline alkaloids have not yet been isolated from several other Australian species, probably because of decomposition during drying of samples. Extraction of fresh berries is necessary to prevent enzymatic hydrolysis.

The family Convolvulaceae, also of the order Solanales, has overseas representatives with alkaloids, but limited tests of Australian species have so far been disappointing. *Ipomoea muelleri* Benth. gave 0.02 per cent. of crude non-volatile alkaloid (Wilson, personal communication).

Order Personales

Several species of Acanthaceae have given positive alkaloidal tests, not confirmed. An overseas species contains an alkaloid of the quinazoline group (vasicine), and has been used in India as a remedy for asthma (Henry, 1949).

Order Lamiales

There is dubious evidence from spot-tests that one or two native species of Labiatae are alkaloidal. In Myoporaceae, *Eremophila drummondii* F. Muell. gave 0.02, and *E. fraseri* F. Muell. gave 0.25 per cent. crude alkaloid (White, personal communication).

MONOCOTYLEDONS

Order Liliales

In the tribe Uvularieae (family Liliaceae), two endemic genera contain alkaloids. These are *Kreysigia* and *Schelhammera*. In the same tribe occurs *Gloriosa*, containing colchicine and two other alkaloids. Colchicine is used in cytology (Henry, 1949). Examination of *Kreysigia multiflora* Reichb. is proceeding, and two alkaloids, which may be related to colchicine, have been isolated (Rodda, personal communication). *Iphigenia* (tribe Iphigenieae) gave positive alkaloidal tests.

Order Amaryllidales

Several native *Crinum* spp. (Amaryllidaceae) contain alkaloids, among which lycorine has been identified (Lahey, personal communication).

Order Orchidales

Limited spot-tests of Orchidaceae indicate that alkaloids may occur in certain species, but the chemistry of the group is little known.

In other groups, limited testing of Palmaceae (Palmales) was negative. Several Lycopodiaceae (Pteridophyta), which are not Angiosperms, were also negative, although alkaloids are known to occur in overseas species.

DISCUSSION OF RESULTS

The significance of the alkaloid survey for organic chemistry, and where known, for pharmacology and human and veterinary medicine, has been briefly indicated under each alkaloidal group. It is evident that the alkaloid potentialities of Australia are extensive and varied. More complete and systematic spot-testing might be profitably undertaken in families such as Compositae, where alkaloidal species occur only sporadically, and where generalizations from the results of only a few species in the genus or tribe are risky. Much more work, not only by pharmacologists, but also by chemists in alliance with field botanists, is obviously required to solve the many problems encountered in stock poisoning, variation of samples, and therapeutic use of characterized compounds.

The alkaloid survey also has important botanical implications, several of which may be mentioned.

Certain of the results provide examples of the value of chemical data as an aid to the classification of plants. Samples placed under *Zanthoxylum brachyacanthum* F. Muell. and *Z. veneficum* Bail. yielded the same four alkaloids. Critical revision of these two "species" suggests that probably only one species is represented (*Z. brachyacanthum*).

A tree recently found in North Queensland came closest to specimens of *Daphandra aromatica* Bail., but botanical opinion (including evidence from wood anatomy) was that the tree may represent a new genus. It yielded a new alkaloid, not found in any *Daphnandra*, but which was the sole constituent of *Dryadodaphne novoguineensis* (Perk.) A. C. Smith from New Guinea. Thus chemical evidence was able to supplement botanical opinion that the Queensland plant was best placed under *Dryadodaphne novoguineensis* or a closely allied species endemic to north-eastern Australia.

The alkaloid chemistry of *Gyrocarpus americanus* Jacq. and various *Flindersia* spp. also provides valuable confirmation of their amended botanical classifications. For instance, the occurrence of furoquinolines (a restricted group) in *Flindersia* and certain members of the tribe Xanthoxyleae (Rutaceae) does not support suggestions that *Flindersia* be placed in a separate monotypic family. Rather, the

alkaloid data vindicates Robert Brown's original view of the close taxonomic connection between the two groups.

Ecologically, it is instructive to compare the alkaloid potentialities of the various formations in Australia. There seems little doubt that rainforests contain the highest proportion of alkaloidal species. There are over 300 species of trees alone in Queensland rainforests. These, and the shrubs, vines, epiphytes etc. belong to a great variety of families, which includes most of the known alkaloidal families. On the other hand, arid or subhumid formations contain relatively few alkaloidal families. In these formations, communities are dominated by one or few species, generally belonging to families such as Myrtaceae, Proteaceae or Gramineae which are of no alkaloidal interest.

A comparison of, say, a heath community near Keith, South Australia, and a mature tropical rainforest in North Queensland is instructive. The heath contains about 100 species of flowering plants. Although not all these species have been tested, a reasonable inference on the basis of their affinities is that none, or at most one or two, yields alkaloids. On the contrary, the tropical rainforest has perhaps four- or five-fold the number of Angiosperms, as well as a far greater number of lower plants. Among the Angiosperms, there may be 5-10 per cent. of alkaloidal species.

Since heath and rainforest share few genera, closely related species in both habitats cannot be properly compared for alkaloids. Shared families include Leguminosae, Liliaceae, Myrtaceae, Pittosporaceae, Rhamnaceae, Rutaceae, Proteaceae, Dilleniaceae. Of these, Rutaceae, Lilaceae and Leguminosae are known alkaloidal families, but their South Australian heath representatives are negative. In other words, the evolution of existing genera in these shared families has been associated with a certain development of alkaloids in rainforests, and absence of alkaloids in the heath. The nitrogen metabolism of both groups is accordingly different. Different climatic and edaphic factors may be indirectly involved. Thus, the South Australian heath soils have a poor nitrogen status (max. 0.053 per cent. N) (Coaldrake, 1951), whereas rainforest soils near Atherton, North Queensland, derived from basalt, have 0.54-0.61 per cent. N (Teakle, 1950). On the basis of the results discussed in this paper, of 26 families in which alkaloids are certainly developed, 16 are tropical and subtropical, and 10 are widely distributed, including the temperate regions. McNair (1935) calculated that three times as many alkaloidal families were found in the tropics as in the temperate zone, but the ratio of positive to total families was nearly the same in both zones. In the tropics, the greater diversity of plant types apparently accounts for the greater abundance of alkaloids. These discussions are extended in another paper.

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FARM MANAGEMENT RESEARCH IN AUSTRALIA

By D. B. WILLIAMS

I.

Introduction

Farm management research concentrates on costs and income trends on farms, and on the factors which influence income levels on farms. These factors include the organization of the farm in terms of farm size, land tenure, amount of capital invested and the choice of enterprises; they also include efficiency of production in terms of output per man, per acre and per farm.

Several events in recent years have drawn attention to the importance of farm management research in Australia. Its rise to prominence has been encouraged by the emergence of agricultural economics as a separate social science in Australia, since farm management is an integral component of this broader science of the economics of agricultural industries.

At the same time, the rapid and epoch making changes in postwar economic conditions have caused many changes on the farms of Australia and have drawn attention to the relationship between economic conditions and changes in production levels and techniques on individual farms. The impact of material shortages, the growing emphasis on soil conservation, the effects of high wool prices on other farm enterprises and the publicity about taxation problems have all thrown emphasis on the need to understand and interpret the economics of production on the thousands of individual farms in Australia.

More recently, the emphasis on extension work and the importance of the national food production drive has emphasised even more the importance of farm management as a guide to the most effective programmes which might achieve these ends.

An interpretation of the present position in Australia in the light of developments in farm management in the United States may assist in the definition of desirable procedures to be followed in the future development of this work in Australia.

The development of farm management in the United States reveals a gradual maturation of ideas, as well as the impact of outstanding economic events in the fifty years during which the science has been developing. (Case and Williams, 1951.) It is helpful to recognise and interpret the different stages of thought in their context of time and accompanying events, so as to avoid a tendency to copy procedures and attitudes and apply them in Australia without recognising that these very procedures and attitudes were developed as a result of special problems which existed from time to time in the United States.

Nevertheless, there is much to learn from overseas experience. The great need is for adequate understanding of the usefulness and limitations of each technique of research or extension used in farm management work.

D. B. WILLIAMS is an officer of the Bureau of Agricultural Economics. *This paper is based in part on the T. L. Pawlett lectures delivered at the University of Sydney in June* 1952, *and records some of the results of the author's tenure on this scholarship and the Booth Fellowship at the University of Illinois,* 1948-1950.

Farm Management in the United States

The one central theme underlying farm management in the United States has been the desire to provide a better extension service for farmers. This position arose because agriculturists took such a leading part in the development of farm management in the United States, and because ample funds were available for extension work after the passage of the Smith-Lever Act in 1914. This emphasis on extension was the inspirational origin of the work on model farms early in the century; it underlies the successful use of supervised account books at the University of Illinois and elsewhere; dissatisfaction with existing procedures as extension tools led to the development of farm budgeting in the 'twenties, which was the forerunner of much of the farm planning extension work now conducted on behalf of government agencies concerned with adjustment programmes, soil conservation and rural credit. Continuous pressure on farm management workers has existed—a pressure to provide practical interpretations of the farmer's problems and answers to his queries as to how to increase farm income or to develop better land use programmes for his farm. This has forged a link between research and extension work in the United States. The close co-operation between Federal and State employees in the conduct of agricultural economics research and the widespread intervention of government agencies in adjustment programmes have encouraged the application of farm management data on a wider scale than to the solution only of individual farm problems. Farm management has also made contributions to agricultural policy, for national policies must be founded on accurate interpretation of the responses to economic change of all of the farms in the nation. Research in farm management has enabled these responses to be interpreted, and has defined the factors which influence them. The contribution of farm management in the policy field has been to express the national need or national policy in terms of their effects on individual farms. This involves an appraisal of the production problems on farms and of factors which determine how farmers react to different kinds of changes. Farm management can provide a similar service and achieve identical status in Australia.

There have been other influences in farm management in the early years of its development. The application of the principles of economics to farm management supplemented the work of the agriculturists who had founded farm management by turning their interest towards problems of efficiency of economic management as distinct from problems of technique of production.

Farm management has thus been developed along two broad lines—by economists and by agriculturists. In recent years there has been a tendency toward fusion of the two sciences, but some evidence of the two-way approach originally adopted by the founders of the science, still persists in present-day thought on the subject. Indeed, different Universities can still be characterised according to the relative emphasis placed on each approach, although the establishment of separate departments of agricultural economics has done much to merge the two sciences.

The practical significance of this union of social and natural sciences is suggested by research trends within the United States Department of Agriculture. Approximately one dollar in every five spent on research in 1949 was spent on social science research. This was within the Department of Agriculture alone, where most of the natural science research is concentrated. The social science research conducted there is also supplemented by research conducted in other agencies which concentrate on social sciences.

The Australian Position

In Australia, the position is quite different. There is no tradition of accumulated past experience or cleavages into different schools; economists have made

few contributions to the understanding of problems of farm management. Indeed, by their naive acceptance of the idea of "the higher the price the lower the production", many economists have committed the most heinous of all crimes of social scientists—the extension of their conclusions to fields beyond their own empirical knowledge. Under the guise of economic analysis they have made guesses as to relationships without full knowledge of all of the empirical variables affecting the situation concerned at the particular time under consideration.

Furthermore, the interest in farm management in Australia has not arisen from pressure from agriculturists for more realistic interpretations of farm production problems. The underlying link between farm management and extension work so evident in the United States has not yet been forged in Australia.

Instead, farm management in Australia has so far grown with agricultural economics, as part and parcel of the requirement to understand more accurately the economics of production on farms. The use of farm management data in agricultural *policy* has dominated the development of the science in Australia except for some rather unsuccessful attempts to establish record keeping systems.

This lack of emphasis on extension work explains the almost complete concentration on cost of production studies in Australia by farm management workers. The lack of pressure from extension work, and the undeveloped state of agricultural economics in Australian Universities have meant that there has been little or no application to such procedures as farm budgets, studies of management efficiency, land use, efficiency of labour and machinery on farms, or reasons for variations in farm income. Useful as budgets for War Service Land Settlement have been for administrative purposes, they are a different genus from a well-developed farm plan which takes account of difficulties and problems of the actual farm concerned. Nevertheless, extension work has proceeded without the backing of much of the economic information on which it should be founded if it is to strike a realistic note to farmers. It is therefore proposed to pause in the course of this general review of farm management to illustrate the application of some of the principles outlined to the use of "Model" or "Demonstration" farms.

The Model or "Demonstration" Farm

The model farms were the first method of extension work in farm management used in the United States. They enjoyed their boom in the first decade of this century, and were then replaced by other methods as their inadequacies and weaknesses came to be revealed.

Spillman (1902) defined the principle of the "model farms" as follows:—

> "Here and there in all parts of the country farmers can be found who are highly successful. True, their success is generally due to unusual executive ability, but this is simply saying that they have answered the questions propounded in the above definition of farm management and answered them correctly for their conditions. There is no more fruitful field of study than the methods and results of these men."

As the farm's whole organization and management systems were used for extension purposes, visiting farmers soon became critical if any weakness in the technical procedures used was to be found. More important, the tendency was to select better farmers whose problems were quite different from those of other farmers. In particular, the stage of development of the farm, and the capital at the disposal of the farmer were often exceptional, so that the problems of the model farm were not comparable with those on other farms. Each demonstration farm had economic (e.g., capital available, attitude to borrowing, land tenure system) and sociological features (e.g., age of farmer, family labour available) which

were its own individual characteristics so that the methods used and results obtained may be quite inapplicable elsewhere. Indeed, the demonstration farms suffered the weakness, from an extension viewpoint, that they had some of the aroma of "government" farms.

Experience with these model farms revealed that they were an effective means of demonstrating some *individual practices* providing three important criteria are met. First, the problem originally facing the farmer must be defined and the characteristics of this particular farm which influence adoption of any of the alternative solutions available should also be outlined. Secondly, the solution provided in the form of the "demonstration" must be tied back both to the original problem and to the factors which influenced the particular solution chosen for this farm. Other solutions might be more applicable elsewhere where different conditions prevail. Thirdly, details of the costs and returns of demonstrated practices should be available.

The emphasis can then be turned to the solution of individual farmer's problems in the light of resources available to him. To attempt to establish a whole model farm on which all operations are demonstrations is to invite criticism from the very farmers it is designed to impress. To supply large quantities of capital for the purpose is to remove the farm even further from the realms of feasible achievement for other less fortunately endowed farmers.

The general theme of these comments can be applied with equal force to the crop-growing competitions which as every extension officer knows can consume much time. The competitions are confined to a specially selected group of farmers and avoid the real economic problems of the remainder by ignoring any costs of production involved, and ignoring the way in which the crop grown can be fitted into the remainder of the farm programme or even the differences in soil types. Similarly, farm competitions which ignore income levels and the capital resources of the farmers concerned cannot be meaningful to other farmers unable to indulge in such luxurious hobbies. The competitions publicise techniques of production, with little emphasis on economic problems involved. Their great disadvantage is that they make such heavy demands on the time and energy of extension officers who could be better employed doing other things.

These examples provide some understanding of the importance of farm management when the "practical" problems of farmers are considered. This understanding may be reinforced by a review of some of the more important components of the body of farm management principles which has been built up over the years.

Cost Studies and Costs of Production

Analysis of costs has been the core of farm management research since the earliest days. To a very large degree, the history of farm management is centered on the history of methods of obtaining, measuring and interpreting farm cost data. While prices of cost items are largely beyond the farmer's control, it does not follow that the costs of production are also beyond his control. Great variations in efficiency and in earnings are generally observed in any group of farmers, and many of these differences can be attributed to differences in management practices and farm organization. It follows that there is scope for improved efficiency—quite apart from new inventions—if the managerial problems associated with the less efficient systems of production can be overcome.

In the early years of the development of farm management—both in the United States and in Australia—much of the impetus for cost studies came from those who sought to compare absolute costs per unit of production with prices received

by farmers as a measure of the welfare of farmers, and as a basis for a prices policy.

By 1933, when the A.A.A. was introduced in the United States the emphasis on costs alone as a basis for pricing policies had been replaced by the parity concept. Thereafter farm management data came to be of less importance in *prices* policies, and farm costs studies were used more as a basis for estimates of farm income earned and as a measure of changes in costs and techniques of production over long time periods, and between different areas and different systems of farm management. Moreover, an important alternative role in the policy field remained for farm management research—to appraise the trends in farm efficiency and production techniques, and to provide accurate analyses of the effects of alternate price policies or trends in economic events on levels and patterns of production on farms.

The collection of cost data from farms was therefore left to those who sought to concentrate on management problems and efficiency of production. Such problems of efficiency of production had been in the forefront of the minds of the agriculturists who had founded the science of farm management in the early days. They sought to determine the costs and profitability of different farm enterprises, and to measure how different enterprises affected the farmer's income.

The passage of time has led to gradual evolution of ideas as to how such cost data should be interpreted.

Long and Short Term Costs in Farm Planning

The interpretation of cost data was clarified by the economists' emphasis on the difference between long and short term costs of production. The long term costs are those which would occur if all factors of production were considered to be "mobile", so that it is feasible to add together such a wide category of costs as rent of land, depreciation on improvements, labour costs, and operating expenses, expressing each in terms of a cash cost regarding the total as the (long term) cost. Such costs are useful in comparisons of trends in costs over time, and in comparisons between areas in costs, as well as in showing the trends in relative importance of the different components of cost. What these costs do not show is the relationships between enterprises and the cost components which a farmer actually compares when deciding whether he will grow product A or product B. For these purposes, short term costs are nearer the mark.* These represent the variable costs, subject to the farmer's control, which will be incurred if a specified production programme is undertaken. For example, land and labour costs, and depreciation costs of improvements might be almost identical under two alternative plans of production, and therefore they can be ignored when budgeting costs to compare the two enterprises. In a similar manner, in the short term, the degree of fixity of resources on the farm limits the amount of adjustment that can be made on the farm. If overlapping amortisation periods occur, the successive replacement of fixed assets, which impose rigidity, may develop into an influence tending toward rigidity in the production programme.

From the viewpoint of the individual farmer using cost data to guide his farm operations, the key question is the nature of the "input-output" curve or of the "production function" which applies to his farm. This simply measures the response in output to increased application of variable factors, and emphasises the need to define, for example, *how much* additional fertilizer or feed to add to the soil or to an animal. Most of these production functions follow the law of diminishing returns, and their estimation

*For a discussion of the relationship between long and short term costs, see E. O. Heady "Uncertainty in Market Relationships and Resource Allocation in the Short-Run", Journal of Farm Economics, Vol. XXXII, No. 2, May, 1950.

is primarily the responsibility of the agriculturist,† by means of experiments. One of the difficulties in interpreting farm management problems is to define the point at which increased levels of applications of fertilizer or feed are no longer profitable to the individual farmer. Much information suggests a general need, without indicating how soil type, managerial skill and capital supplies limit the ability of farmers to follow recommendations. If emphasis is turned toward responses in output as changes in levels of input of fertilizer, machinery, labour, etc., are made, then attention comes to be concentrated on *changes in rates* of application rather than significance of alternative *different* treatments.

Farmers are motivated to a greater or lesser degree by economic considerations, though social factors also influence these decisions. Farmers seldom have enough land, labour and capital to do everything they would like, much less everything extension agents want them to do. The key to successful extension work rests in recognition of the role of each particular practice in the whole operations of the farmer. This in turn depends on an understanding of the nature of costs on farms, and particularly the extent to which available factors of production are specialised or fixed in nature so that opportunities for alternate use on the farm are limited. The other key problem is that of liquidity and working capital, and the effect of any new proposal on risks to which the farmer is exposed.

These considerations lead to emphasis on the individual farmer's problems, and the way in which generalisations have to be modified to meet the unique circumstances on each farm. Two aspects of this problem—budgeting and the management function—will now be discussed.

Farm Budgeting and Farm Planning

The emphasis on budgeting in the United States arose in part from dissatisfaction with "cost-of-production" studies as a means of establishing the merits of alternative systems of farm organization or management. What was needed was a system to establish the merits of alternative plans which a farmer could adopt. To meet this need, why not estimate on paper the costs of each method of production, and compare with the expected returns?—this would provide an estimate of farm income under alternative plans. This budgeting technique depended on the costs studies for the facts on which the budgets were based, but it threw the emphasis on to the operation of the *whole farm.* Previously, in cost analyses, there had been a tendency to estimate costs for single enterprises or commodities. By restricting the analysis to single farm enterprises, there was a tendency to under-estimate the importance of the relationships between the major and minor enterprises on the farm. These relationships undermined the usefulness of costs of production studies *as measures of efficiency of production.*

A great impetus to the budgeting studies was given by the adjustment programmes of the 1930's. These programmes were introduced in an effort to reduce supplies of agricultural produce to the low level of purchasing power prevailing at the time. This tended to throw emphasis on efficient land use, a trend which was reinforced by the expansion of soil conservation work.

As the adjustment programmes introduced during the depression developed, farm management came to have new importance in interpreting the role of the individual farmer in the nationwide planning programmes. No longer was the science of farm management restricted to

†For some discussion of this problem, see H. R. Tolley, J. D. Black, M. J. Ezekiel, "Input as Related to Output in Farm Organisation and Cost-of-Production Studies". U.S.D.A. Bulletin 1277, 1924.

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E. O. Heady, "Elementary Models in Farm Production Economics Research". Journal of Farm Economics, Vol XXX, No. 2, May, 1948.

discussions of how to increase profits for the individual farmer. It began to include a wider range of problems associated with farmers' relationships in the economic environment. Witness some comments from annual reports of the chief of the Bureau of Agricultural Economics in the 1930's:—

For example, in 1932:—

> "In research in farm management and costs the bureau attempts to find ways and means of making farming more successful. In doing this, it studies the internal financial and technical organization of farms, farm practices and efficiency, and farm costs. It also studies the external factors affecting the medium in which the individual farmer carries on his business."‡

By 1939, a new aspect of farm management was a major part of the work:—

> "A considerable part of the Bureau's work in farm management emphasises fact finding and planning for agricultural programmes. It aims to construct a more adequate factual and analytical foundation of knowledge regarding various farm situations and problems. The Bureau has undertaken to determine the economic problems of internal organization and operation of farms in problem areas and to appraise the relation and effect of various agricultural programmes on these problems, as a basis for a better use of the farmers' resources in terms of economic welfare of farm families and of the Nation."§

One permanent effect of the adjustment studies has been the emphasis on farm planning, and efficient land use. Within each type of farming area the major forms of farm organization were known, and the suitability of different soil types to particular intensities of cropping were more thoroughly analyzed. Farm planning or budgeting was used to estimate the effect of adjustment programmes on the individual farmer's problems, and a continued emphasis on this work, and on soil conservation, led to the use of the land-use capability classification as a basis for individual farm planning. This emphasis on farm planning depended on the supply of current data relating to costs and incomes. It also encouraged the development of standards of performance (e.g., output per animal, yields per acre, productivity of labour), which can be expected from different farms, based on analysis of records kept on farms of a similar size, tenure status, and with similar combinations of farm enterprises.

The intervention of government agencies in individual farm operations during the 1930's can be gauged from the fact that by 1939, one farm in every six in the United States was receiving some assistance from Government authorities in the planning of its operations, to establish the worthiness of the farm as a credit risk or to fit into some Government adjustment or soil conservation programme.

The development of individual farm plans, based on accumulated results of research into costs and returns of different combinations of farm enterprises is one of the major tasks facing research and extension workers in Australia. The first step is to establish research which provides a continuous flow of data relating to economic conditions on farms.

The Management Function

In recent years the emphasis which economists have placed on uncertainty in the interpretation of production problems of firms has led farm economists to emphasise this same attitude in their own work. The attention paid to dynamic economics, in which *time* is taken into account, has increased understanding of production problems on farms and has reinforced the emphasis on the problems

‡Report of the Chief of the Bureau of Agricultural Economics, Washington, U.S.D.A., 1932, p. 21.

§Report of the Chief of the Bureau of Agricultural Economics, 1939, Washington, U.S.D.A., 1939, p. 13.

of individual farmers as distinct from generalisations about groups of farms.

The major contribution of recent advances in dynamic economics has been in its emphasis on the management function. While farm management has been studied on a systematic basis for over 50 years in the United States, relatively little attention has been paid to one of the central themes of the subject—that of management itself. What does management mean, what are the functions of management, and what are the features of an efficient manager? How do farmers make decisions? The relevance of these problems to extension work is obvious.

Much of the agricultural and management advice given to farmers in the past has been founded on the physical operations necessary to achieve increased output. The effect on, or limitations imposed by, a farmer's financial condition have seldom influenced the recommendation. The extension agent may have altered the general recommendation to suit the individual, but he has been left to his own devices so to do. Now there is implicit in such an approach an assumption that no limitations on following the advice are imposed by such factors as the farmer's capital resources, or his attitude toward risk. The purchase of the new bull, the addition of fertilizer, the planting of a farm woodlot and the removal of crop land to pasture, are all decisions which involve tying up capital. The farmer's liquidity is reduced. In other cases the choice of which crops to grow, which livestock to feed, and how long to feed them, are decisions which involve risks which a farmer must be prepared to run if he is to produce that particular enterprise rather than another. It follows that advice which may be acceptable to one farmer is not "practical" to another, for he cannot afford to allocate the necessary working capital for the purpose or to prejudice his liquidity or to run the risks involved. Livestock feeding involving use of large quantities of grain is one of the most striking examples of this principle, since changes in feed/meat ratios will have great effects on the profits ultimately realised.

The important new variable which is introduced by these "practical" problems is that of uncertainty associated with the passing of time. It can, in fact, be argued that in the absence of uncertainty as to the future there would be no management problem at all. This follows from the distinction between technological production methods themselves, and the changes in these methods which are necessary because the future outcome of the methods is not known with certainty. If the future events were known with certainty, then present expectations of these events would be correct. Hence production processes could be worked out to produce goods as required for the future, the results of which would be known with certainty. In this case management would be purely technological, and the economic management function would disappear. It would disappear because input-output relationships would be known, and future demands would be known so that once the needed production process was chosen, no economic problem would remain. The choice of resources would be automatic, given certainty as to the future, and knowledge of input-output relationships.

Thus the economic management function emerges as a means of adapting farms' operations to uncertainty and to change. Farm economists should therefore accept the challenge to define the effects on choices between alternative production methods of farm organization such as size and capital supplies available, since these are so closely related to ability to run risks—and incidentally, to willingness and ability to follow extension recommendations. Similarly, differences may exist among farmers as to their willingness to run risks. Again, a more important influence is the different *expectations* formed by farmers as to the likely trend

of future events. All of these variables may affect a farmer's response to a recommendation which relates to farm operations.

The importance of these influences on management decisions have been reflected in recent years in the increased attention to the components of the management function. The existence of risks implies that one of the functions of management is to deal with these risks, and to lighten their incidence on the farm.

If the effects of risks and uncertainty are to be fully recognised, increased attention needs to be devoted to the question of *expectations* formed by farmers and the way they affect *decisions*. Farmers expect prices of different commodities to change, seasons to develop, and costs to alter. On a basis such as this, they choose the best of the courses available to them, in view of their fixed resources of capital and managerial skill. As Johnson (1950) has stated, five of management's functions are "observation, analysis, decision making, action, and the acceptance of economic responsibility".

Some empirical work on the level expectations formed by farmers in the United States indicates that their price and yield expectations are formed, largely, on the basis of immediate past experience. Some enquiries in Australia suggest that the *direction* of expected cost and price trends is based on rational and informed knowledge of factors influencing future prices (Williams, Parish and Bollen, 1953). This problem has more than an academic interest because, if solved, it would facilitate the estimation of responses by farmers to price changes and to other incentives. A clearer understanding of this chain of events would facilitate prediction of responses. The details of these investigations have been reported in the literature and some progress is being made in defining how farmers form their expectations and attitudes and how these expectations and attitudes influence their actions. (Williams, 1951).

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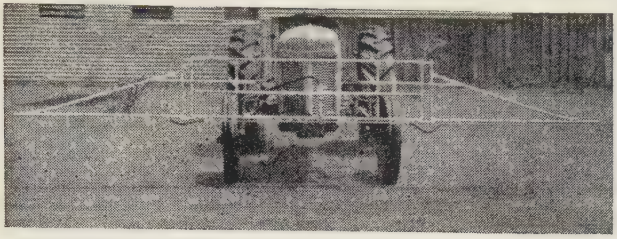

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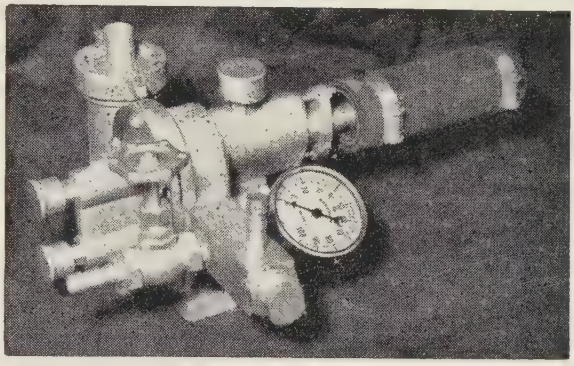

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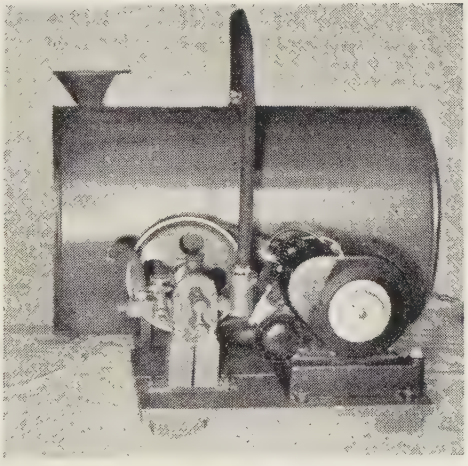

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THE BRIGALOW COUNTRY AND ITS IMPORTANCE TO QUEENSLAND

By P. J. SKERMAN

Introduction

I have chosen this somewhat non-technical title under which to discuss Queensland's twenty-three million acre belt of country which originally carried virgin brigalow scrub and other scrub associations of which brigalow comprised an important component.

Brigalow (*Acacia harpophylla*) is one of the several hundred species of Acacia recorded in Australia. Although the species has not been closely studied botanically there appears to be some considerable strain variation. In scrub formation where growing on fertile soil the tree grows very erect to a height of some sixty feet with a dense canopy of phyllodes at the top. In open formation it grows into quite a shapely shady tree some twenty-five to thirty-five feet high. On poorer soils or on soils very poorly drained, a dense understorey of whipstick brigalow about ten to fifteen feet high may develop. The tree bears an elongated jointed pod but the production of pods is relatively rare and must be governed by fairly strict climatic conditions. Bentham, in his "Flora Australiensis", reports that the pods are unknown; but pods have been collected in many parts of this State and in New South Wales. The usual method of spread is by the production of suckers growing vertically from the roots—a single tree giving rise first to a clump and the clumps merge to form a dense scrub. The production of suckers is greatly increased by the passage of fire and many mistakes were made by the early settlers who tried to clear brigalow scrub quickly by falling and firing as soon as the fallen material was dry enough to burn. The legacy from such practices can be seen in the thousands of acres of sucker regrowth which cause so much concern to landholders at the present time.

The brigalow does not develop a well-defined taproot, the usual root being a "hockey-stick" type resulting from development from suckers. Consequently the tree is generally shallow-rooted and a large proportion of the dead trees fall or can be pushed over easily five years or more after death.

The brigalow is not an important timber species, but is usually freely made use of for rails in stockyard construction. It does not last in the ground and is not used for fence posts. As a firewood the timber is easy to chop, burns readily to a white ash and produces a hot fire.

Ecology of the Brigalow Scrub

The ecology of the brigalow deserves a much closer study than has been accorded it hitherto. There appear to be temperature, rainfall and soil factors involved in the determination of its distribution. Brigalow can occur as an

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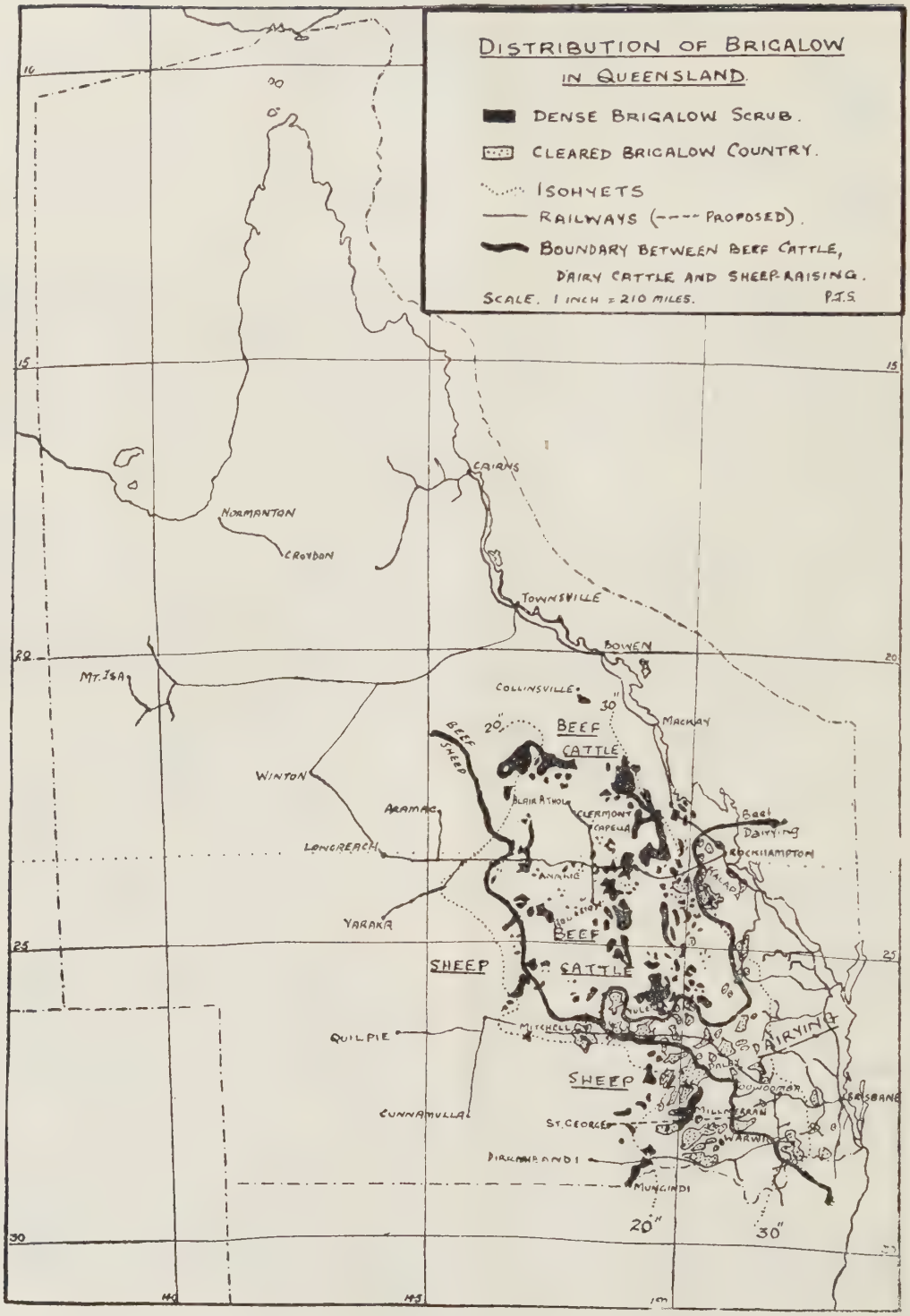
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20"
30"

almost pure stand in thick scrub formation, in scattered clumps in open grassland, or variously associated in scrubs with belah (*Casuarina lepidophloia*), wilga (*Geijera parviflora*), box (*Eucalyptus populnea*), buddah or sandalwood (*Eremophila Mitchellii*), softwood scrubs (*Flindersia, Croton* spp., etc., in addition to the Bottle Tree (*Brachychiton rupestris*), tea-tree (*Melaleuca pubescens*), limebush (*Eremocitrus glauca*), Yapunyah (*E. Thozetiana*), Yellowwood (*Terminalia oblongata*), Gidgea (*Acacia Cambagei*) and several other species including an understorey made up of Currant Bush (*Carissa ovata*) and Ellangowan poison bush (*Myoporum deserti*).

In Southern Queensland the usual scrub association is brigalow-belah-wilga, brigalow-box-wilga or brigalow and softwood. In the Goondiwindi area a brigalow-belah-limebush association is common, with brigalow-tea tree in the wetter areas. In the Central districts extending from Kalapa westwards to Anakie and from Rolleston north to Clermont, a brigalow-yellowwood association is dominant with an understorey of currant bush and Ellangowan poison bush. North of Clermont towards the Suttor river a brigalow-gidgea association is found, apparently in response to the higher temperature.

Distribution of the Brigalow Belt

The "brigalow belt" extends some five to six hundred miles in a north-south direction in Queensland from Collinsville to the New South Wales border, and extends another two hundred miles or so southwards into New South Wales. In width the belt extends approximately two hundred miles. The distribution is indicated on the accompanying map.

The major portion of the brigalow country is contained within the 146th and 151st parallels of longitude, and the 21st to the 29th parallels of latitude and lies within the 20-inch and 30-inch isohyets. It is interesting to compare the map of the brigalow areas with the distribution of the prickly pear throughout the State as mapped by the Prickly-pear Land Commission when it took office in 1924. There is a remarkable similarity, especially between the distribution of the dense brigalow scrub and dense prickly pear. Of further interest is the fact that brigalow ash contains up to 95 per cent. of calcium carbonate. Prickly pear leaves, growing in similar soils, contain a heavy concentration of sphaeraphides of calcium oxalate. Furthermore the excreta of the *Cactoblastis* caterpillar consists almost exclusively of these sphaeraphides of calcium oxalate! It is interesting to speculate as to whether Rhodes grass, which does so well in recently burnt brigalow scrub areas, might not have some special lime status.

Topographically the brigalow areas occur at altitudes from just above sea level to 1,500 feet with the main occurrence between 500 feet and 1,000 feet. At higher altitudes it usually gives way to softwood scrub or open forest. In local areas it occupies the lower slopes and foothills below the Eucalyptus whereas on relatively flat terrain such as near Warra and Tara it is found just a few feet higher than the drainage lines occupied by box (*Eucalyptus populnea*) or, in wetter areas, Coolibah (*Eucalyptus microtheca*).

Geological Relationships

The relationship between the occurrence of brigalow and geology is close, and in Queensland the brigalow appears to have a close connexion with the occurrence of calcareous shales and sandstones and coal measures and alluvia derived from them. The Walloon series figures largely in the geology of the brigalow areas. Because of this affinity the waters underlying most of the brigalow areas are very deep and of very inferior quality. Occasionally an artesian flow is obtained but as the areas form important intake beds for the Great

Artesian Basin pressures are usually insufficient to provide flowing bores. Methane gas often gives a good deal of trouble in the bores sunk into the brigalow areas. Consequently most of the water supplies are provided either by natural surface storages or by excavated tanks. The location of tanks is important as the loose self-mulching soil on some of the catchment areas reduces run-off and on the flatter land the presence of large "melonholes" may prevent all run-off except that of flood waters. Many tanks are located on the edges of hard lateritic ridges or ridges of the Blythesdale series, both of which give a quick and effective run-off.

Soils of the Brigalow Belt

The soils of the brigalow country can be broadly grouped together as grey, grey-brown or red-brown calcareous loams, clay loams or clays. There is, however, considerable variation within this broad classification. In rare instances the soil may be acid throughout the profile and in such cases the soils must be regarded as atypical. There may be an extension of brigalow growth into such soil types but development of the tree is generally retarded. The soil at Carinda listed by Beadle (1948) as growing brigalow had a surface pH of 6.0 decreasing to 3.9 at a depth of 14 inches. This is atypical. The reddish-brown lateritic clays near the western edge of the brigalow belt at Bungunya are also acid on the surface but here again the brigalow is of the stunted "whipstick" type. In general, it can be said that the soils are usually alkaline, the pH increasing with depth especially where solonisation has occurred.

The texture of the surface soil is usually heavier than a loam although in areas where belah is dominant a sandy loam surface may be encountered. Most of the soils carry a surface mulch and in almost all cases the subsoil is a heavy and somewhat massive clay. The soils are well charged with bases and free lime is usually present in the profile. Some gypsum may occur below the lime layer. Many brigalow soils are high in exchangeable sodium especially where buddah (*Eremophila Mitchellii*) is present. Jensen (1921) believed that the accumulation of "white alkali" (sodium sulphate), black alkali (sodium carbonate) and salt (sodium chloride) on the surface of brigalow soils collected in the Roma district prevented the germination of other tree seeds and favoured the brigalow. I have not been able to confirm Jensen's results in relation to common salt in samples collected between Clermont and Dalby.

The available phosphate in brigalow soils is frequently on the low side for agriculture and some phosphate deficiency has also been demonstrated by blood analyses from stock depastured on such country. Where there is some basaltic influence nearby such as often happens on the Darling Downs or where the areas are seasonally flooded, the phosphate status may be much better. Copper deficiency in sheep has been reported from the brigalow country in the Tara district.

A feature of a good many of the brigalow soils of alluvial origin is the presence of numerous "melonholes" or "gilgais". Such occur also on the black earth plain country but they appear to reach their maximum development in the brigalow country where melonholes some five feet deep and fifty feet in diameter may be continuous for miles. It is generally believed that the cracking of these heavy montmorillionite clay soils in dry weather and the sudden expansion when wet during periods of heavy rainfall sets up a churning and folding effect which produces the melonholes. On brigalow country at Bybera near Inglewood it was found that the volume expansion of the surface soil when wetted was 20 per cent. whilst a sample from a depth of twelve inches gave a figure of 33 per cent. This would help explain the phenomenon. Whereas the larger melonholes constitute

a hazard for cultivation they are important in preventing heavy run-off and must considerably improve the soil moisture status of the areas.

Land Use in the Area

The brigalow belt is devoted to dairying and agriculture in closely settled areas, sheep and cattle raising in the more distant localities. Although there has been extensive development in portion of the brigalow country I have estimated that of the original twenty-three million acres some sixteen million acres still remain almost untouched. The main reasons for the slow rate of development can be traced back, firstly, to the presence of the prickly pear, secondly, to the generally unsatisfactory water supply position, thirdly, the low ruling prices for cattle until quite recently with consequent lack of capital for development in the cattle country, fourthly, the insufficient supply of suitable labour for ringbarking, clearing and improvements, and latterly, the fact that most of the prickly pear holdings have some ten years or more remaining in their present leases—a fact which has prompted the passage of the recent Land Act Amendment Bill.

In tracing the development of the brigalow country the problems of the dairyman, the sheepman and the cattleman have been somewhat different, and it is convenient to discuss each set of circumstances separately.

Dairying

By reason of smaller areas of 350 acres to 1,500 acres held by the dairyman he was compelled by necessity to attempt to eliminate the prickly pear and prevent its spread. His finances were limited and in the case of leasehold land the rental became a burden. One of the first tasks of the newly constituted Prickly Pear Land Commission in 1924 was to re-appraise and generally reduce the rentals of several thousand holdings.

The dense brigalow and prickly pear did, however, remove one of the dairyman's main financial worries in the form of drought losses with stock, and his growing and dry stock could usually be kept in good condition by eating pear in conjunction with the edible shrubs and trees plus scant ground herbage and grasses in the brigalow scrub association.

With the aid first of poisoning and later the Cochineal insect and finally *Cactoblastis* the pear problem ceased to be of major importance and the landholder was left with virgin scrub plus a tremendous volume of rotting and dry fibrous pear debris accumulated on the ground. Dodd (1940) has estimated that in dense areas some 800 tons of green weight of pear per acre had developed prior to its destruction. This would give the equivalent on an 85 per cent. moisture basis of some 120 tons of dry matter in the form of a mulch. The problem was what to do with this mulch—whether to fall the timber, burn the lot and lose the mulch, or to attempt to conserve the mulch.

Quodling (1930) carried out experiments at Palardo near Chinchilla aimed at conserving the mulch. He arranged to poison the standing scrub by frilling and poisoning with a solution of sodium arsenite and then broadcast grass seed and cover crops in the standing timber. The summer experiment was not very successful because of hasty preparation and insufficient rainfall to thoroughly wet the mulch, but the winter experiment provided a great body of winter cereals and Dwarf Essex rape which yielded up to fourteen tons green weight per acre. Subsequently a good deal of country was sown down to Rhodes grass by this method, although ringbarking took the place of poisoning.

Ringbarking proceeded rapidly following the destruction of the prickly pear, and landholders had by this time realised that heavy suckering was likely if burning followed too quickly in the wake

of the ringbarking. Ringbarking alone helped the ground flora to find full expression and the carrying capacity of the country was quadrupled as a result of this practice. The time of ringbarking was generally from January to June, but no particular period gave consistent results year in year out. The grasses and herbage which took charge after ringing included brigalow grass (*Paspalidium caespitosum*), a blue grass (*Dichanthium humilius*), various species of *Chloris* such as *C. divaricata, C. acicularis* and *C. ventricosa,* together with some *Eragrostis* and *Sporobolus* species. The herbage included Creeping Saltbush (*Atriplex semibaccata*), *Bassia* spp. chiefly *Bassia tricuspis,* New Zealand Spinach (*Tetragonia espansa*) and Cotton Bush (*Kochia tomentosa*). There was a marked absence of native legumes. Altogether this flora provided quite useful feed and many properties remained at this stage of development. With the passage of time the brigalow grass has disappeared and the *Chloris* and *Eragrostis* species have dominated the pasturage with an increase in the amount of Cotton Bush, evidence of heavy stocking. The initial fertility following the decay of the pear has been lost and there are signs of general pasture deterioration.

Where further development proceeded the ringbarked timber was allowed to stand to dry for some five years and then the body of dry grass, herbage and timber was burnt. Rhodes grass sown in the ashes of the burn flourished in the early years and where carefully handled has continued to be a most productive pasture in the dairying and some cattle raising areas in the brigalow country.

Those farmers who desired to grow crops sowed maize or cotton with walking stick planters amongst the logs and stumps of the burnt areas and these proved quite profitable as pioneer crops. Subsequent hand-picking, stumping and burning then enabled cultivation paddocks to be carved out of this once thickly timbered country, and now most of the dairy farms are well improved with a proportion of the holding under seasonal cultivation to sudan grass and winter cereals.

Where Rhodes grass persisted and was well handled it permitted extremely cheap production of dairy produce and during the recent cost of production survey of dairy products purely Rhodes grass farms in the Jandowae area provided some of the lowest costs of production in the Commonwealth. However, with the gradual loss of fertility in many Rhodes grass pastures the land has been broken up for cultivation. Under cultivation loss of structure in most of the brigalow soils is rapid, and in undulating areas erosion is taking toll. Consequently it is being recommended that Rhodes grass be re-introduced as a 3-4 year ley in a cropping programme to restore soil structure and stabilise the soil. In grazing areas the introduction of 1 lb. of lucerne per acre into Rhodes grass pastures has been shown by the C.S.I.R.O. to lift production considerably.

Sucker re-growth following ill-timed or accidental burning has given dairymen a good deal of trouble, particularly in the Callide Valley, and Nagle has carried out sucker control experiments on a number of properties using mechanical methods of destruction.

Removal of suckers below the ground level with a bull-dozer was proved unsatisfactory as some 5-6 inches of top soil was removed, the earth was left in mounds and subsequent burning of the suckers was hampered. Breaking off the suckers at ground level was unsatisfactory as sucker re-growth was heavy and small suckers were merely bent over. On partially cleared land which had reverted to suckers a fire plough blade attached to a road grader cut the suckers 4 inches below the ground and after burning the land was brought back into cultivation.

Subsequent investigations by other departmental officers showed that breaking off or cutting of the suckers should be avoided and a method of treatment was evolved whereby a 4-disc plough, equipped with a special bumper bar, passed over and bruised the suckers, following which some 80 per cent. died. A heavily weighted disc harrow was run over the area in early summer and saccaline broadcast over the area. At the end of summer the dry trash and remaining brigalow suckers were burnt and the land brought into a satisfactory ploughing condition.

Sheep Farming

In the sheep country the holdings were much more extensive than in the dairying areas and development was not as rapid. However, where capital was available ringbarking was carried out with subsequent clearing and limited cultivation. The provision of water and fencing against dingo attack made heavy demands on the grazier's purse and so brigalow clearing lagged somewhat behind. However, where money and labour were available considerable improvement was effected, especially in lands adjacent to existing rail and road facilities. Lack of access to remote areas and the great cost of all-weather road construction in this heavy soil brigalow country also hindered development.

The pioneers of the sheep industry in the Goondiwindi area experimented with sucker control by using a heavy concentration of sheep on young sucker regrowth and found that they could exert satisfactory control if other feed was not offering and the stocking was sufficiently heavy. This practice was extended, the brigalow scrub being felled, burnt three to four months later when it was dry, and stocked with sheep immediately afterwards. If the suckers became woody they were unpalatable to sheep and so immediate grazing, while the suckers were just a few inches high, was essential. A further requirement was that water should be available to allow effective grazing of the whole area treated, and the treated area be not too large for the available sheep to handle. Stocking rate was from 1 to 100 sheep per acre according to the amount of suckering, distance from water, etc. The practice precluded the usual sowing of Rhodes grass in the ashes of the burn as the less feed for the sheep along with the young brigalow suckers the better the control. Such sucker grazing for a period of twelve months usually solved the sucker problem and thereafter the natural grasses took over.

In this cleared brigalow country regrowth of limebush (*Eremocitrus glauca*) and tea-tree (*Melaleuca pubescens*), both difficult bushes to eradicate, is now causing concern. In addition, a few poisonous plants have made their appearance, or re-appearance, such as Crown Beard (*Verbescina encelioides*), Wild Tobacco (*Nicotiana* sp.) and Ellangowan poison bush (*Myoporum deserti*). These cause little trouble with paddock sheep but travelling sheep may be affected.

With the development of heavy machinery during and following World War II improved mechanical means of handling standing brigalow scrub have been introduced into the sheep areas. The capital cost of treatment is high, but good wool prices have provided money to be spent on improvement work and with sheep available to handle the suckers after mechanical clearing, much virgin brigalow has been treated during recent years.

The usual method is to pull the scrub down in swathes from two to four chains wide by means of a wire cable or heavy chain drawn between two high-powered crawler-type tractors. Up to ten acres per hour can be handled and all the timber is flattened. Some of the timber breaks off, the remainder is uprooted. Following this treatment the felled timber is burnt when dry and the subsequent suckers controlled with sheep. The cost

is 35/- per acre for pulling alone. Where "whipstick" brigalow has spread amongst open box timber at Bungunya a local grazier has extended the effective cut of his ten-foot bulldozer blade to twenty feet and effected rapid pushing in this manner. Another grazier has rolled suckers too large to graze with a roller fitted with cutting blades, leaving subsequent growth to the sheep. He also controlled young suckers by spraying them with arsenic pentoxide at a strength of ¼ lb. to a gallon of water.

The next step in the development of the brigalow areas in the sheep country must surely be the cultivation of improved pastures or crops. The sheep country within the brigalow belt of Queensland is fortunate in that it has a very reliable rainfall, well distributed with a definite winter component. This allows all-the-year ground growth of different pasture species. Further, most of the soils are deep and these, with proper attention to fallowing, will provide a reasonably safe cropping programme for both summer and winter crops.

It is envisaged that a good deal of this country will soon be devoted to sheep raising in conjunction with fodder crop and grain growing, and the areas will be reduced in size to provide for more settlement. This is the aim of the new Land Act Amendment Act. The main hazard to cultivation would appear to be the presence of large melonholes over a good deal of the area. Where the melonholes are not too deep a few years cropping will gradually level them out. The larger melonholes will present obstacles but the use of a heavy disc plough such as "Majestic", which was used for land clearing in South Australia, may permit a good deal of this land to be cultivated. This initial preparation must be done by contract as it would be too costly for a private individual to undertake.

Should the development of this southern brigalow belt along the lines of grain farming in conjunction with sheep eventuate, some attention will have to be given to transport facilities. It would appear to be the fashion these days to recommend a new railway route but if development is to proceed along these lines the Millmerran line could well be extended to St. George to tap the undeveloped brigalow area and at the same time provide an outlet for any produce from the proposed St. George irrigation area. The map presented will show clearly the development which has already been effected in this area by the provision of the Warwick to Dirranbandi and the Dalby-Glenmorgan lines. The suggested Millmerran-St. George railway would run approximately parallel to these lines and effectively serve the intervening country.

Cattle Raising

The brigalow belt in the cattle raising country is for the most part undeveloped. A few cattlemen have carried out ringbarking improvements, some have planted Rhodes grass to improve the carrying capacity, and some cattlemen are fattening bullocks on such improved country.

Cattle can make good use of brigalow country even in its virgin state. The scrub trees and shrubs provide a good deal of edible forage and feed can be pulled or knocked down and eaten by the cattle. The dense growth also provides shelter in winter. Consequently it is undesirable that all timber be ringbarked or removed, but suitable belts for shade, wind protection and drought reserve should be retained. However, considerable development is necessary. Ringbarking alone will double to quadruple the carrying capacity.

Low prices for beef cattle until quite recently have prevented cattlemen from spending large sums of money on improvements and the lack of labour for ringbarking has further hindered progress. Large-scale mechanical pulling is out of the question in these areas as the cattle will not effectively control sucker-

ing. However, there is a bright spot in the apparent initial success with aerial spraying of hormones to kill brigalow scrub and suckers, which has been initiated by the Department of Agriculture and Stock with experiments at Cypress Downs, Yuleba and subsequently by a landholder on his own account at Brigalow. Aerial spraying with 2,4-D and 2,4,5-T mixture at the rate of 2 or 3 lb. mixed acid equivalent per acre has killed all top growth of both grown brigalow and suckers and appears to have killed the entire trees. In some cases two separate lots of sucker re-growth have died as a result of the one spraying of the original trees. It remains to be seen whether the treated trees are dead and to observe the effect of fire through the treated area at various stages of the destruction. The cost per acre for this experimental treatment was in the vicinity of £3 and it is believed that this can be reduced somewhat for large-scale treatment. A cost of £3 per acre is somewhat heavy for the cattleman but the ultimate result of the brigalow destruction would be of infinite value to the nation.

This raises an important point in connexion with the development of the brigalow country. There are approximately sixteen million acres uncleared and relatively untouched, and a large proportion unwatered. There are two methods of approach—a relatively cheap but slow method of hand ringbarking, waiting for five years or so and then burning and grassing down or cultivating; the second, the adoption of large-scale mechanical and/or chemical methods which will bring about improvement and greatly increased carrying capacity quickly. Both methods are expensive in the long run, the former expensive in time and sweat by the individual lessee, the second in capital outlay.

The development of this fertile brigalow belt should be a national undertaking in the interests of greater production and greater population. It is unfair for us as Australians to expect a lessee in his one life-time to provide the labour and finance necessary to bring his property into full production when the initial clearing of the brigalow and the provision of adequate watering facilities for stock will be largely for the benefit of posterity. Why not provide public finance for these major works and recoup the outlay if necessary, by increased rentals spread over a longer term? The increased wealth resulting from such a procedure may, in the long run, prove that such initial expense could even be written off.

Land Tenure

One final word about land tenure. There has been considerable uneasiness amongst graziers about security of tenure of their properties, and with the passage of the new Land Act Amendment Act this feeling has been accentuated.

I have no doubt in my mind that all Governments are genuine in their efforts to ultimately give security of tenure and present land laws include priority clauses which accommodate these requirements. However, security of tenure does not mean tenure in perpetuity of large fertile holdings. It is unreasonable to expect a young state such as Queensland with the enormous potentialities which lie in the development of such areas as the brigalow belt, to remain in large holdings. The usual leases have been for a period of thirty years. Let us cast our minds back thirty years and we will find that thirty years ago there was no *Cactoblastis,* no large-scale mechanical equipment for clearing, and cultivation was mainly done by horse and plough! What tremendous development has taken place within the period of one thirty-year lease! It is reasonable to expect that further major developments will occur, though perhaps not as spectacular as the record of *Cactoblastis,* within the next thirty years. Killing brigalow with hormones may be a major development and may release millions of acres of now heavily timbered and

little improved brigalow country available for further settlement.

Many pioneers have done a good job on the brigalow country and present lessees will no doubt continue to bring about improvements, but the subdivision of the country into smaller areas is inevitable for some time to come. It is the duty of those in authority to see, however, that adequate notice of possible subdivision is given and sufficient compensation is meted out for improvements made by these men who had faith in the brigalow country and went ahead with development; and to see that they have sufficient land remaining to maintain their interest and those of their growing families in the land wherein their footsteps are rooted.

I believe that the brigalow belt provides the greatest single potential for development of any land in Queensland and we must push ahead with plans for its successful settlement. Although miscellaneous experimental work has been carried out on brigalow soils by various organisations over a number of years, I believe the importance of these areas is such that all plant industry and animal husbandry investigations should be centralised on one well equipped research station located in the heart of the brigalow country. Should the hormone treatment not fulfil its expectations one of the first items of research could well be a thorough ecological and physiological study of the brigalow itself and the palatability and nutritive value of its scrub associates before further large-scale destruction is practised.

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EXTENSION AND CREDIT IN RELATION TO AGRICULTURAL OUTPUT

By H. P. SCHAPPER

Summary

The relevant results of a survey of dairy-farming in the south-west corner of Western Australia are briefly presented. They indicate that an important reason for low productivity and low income of many farmers is inadequate knowledge. Inadequate capital is a further important reason. Many farmers were found to have incomes too low to make borrowing on current terms attractive. Other farmers, with adequate incomes and security and scope for further development, were unwilling to borrow.

The implications of these facts and inferences for agricultural extension and credit policies are discussed.

It is concluded that the "whole farm" approach to agricultural extension and credit policy could be a powerful influence in the drive for greater production from existing farm labour and resources, at both the intensive and extensive margins of cultivation.

Specific suggestions are made that:

(i) Investigations be carried out of the social background of the farming community to be served by extension workers and of the areas of knowledge in various regions and industries upon which extension resources should concentrate.

(ii) The present narrowly technical interpretation of extension be replaced by a "whole farm" approach in which assistance is given in farm organization and management problems. This implies additional training of extension workers in rural economics and farm management.

(iii) Research in farmer demand for credit is necessary.

(iv) Farmer education be expanded with the definite objective of reducing risk and uncertainty elements in farm investment decisions.

(v) There be special terms, and supervision of credit for low income farmers.

Introduction

The facts of the Australian and world-wide need for greater food production are now so well-known and appreciated that they should need little further emphasis. The problem has become largely a matter of determining the best means by which a rapid increase in agricultural output can be achieved economically. This can largely be done and with a minimum dislocation of the rest of the Australian economy by increasing the productivity of the existing farm labour force.

The two concepts, intensive and extensive margins of cultivation, are helpful in this respect. From the viewpoint of the individual farmer there are clearly two sources of greater output: one, at the intensive margin, through the application of more capital or labour (including "know-how") to the existing effective farm area; two, at the extensive margin, through the acquisition of more developed land over which to spread the existing capital and labour.

These concepts form a framework from which to view some of the facts obtained by the writer during a survey of dairy farming in part of the far south-west of Western Australia, and from which is drawn a number of conclusions as to opportunities which exist for increasing production. It is suggested that similar opportunities for increased production may exist over very considerable areas throughout Australia.

In considering such opportunities it is understood that farmers cannot be ex-

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pected to expand their output unless they can do so profitably and without the necessity of working for such long hours or at such intensity that their conditions are grossly out of step with the rest of the community.

Relevant Survey Data

During 1952, 102 dairy farmers, with 10 or more dairy cows which calved in 1951, were interviewed. They were chosen at random from the 1215 such farmers who were farming in the Statistical Districts of Sussex, Augusta-Margaret River, Nannup and Manjimup. These are contiguous districts located in the far south-west of Western Australia and constitute the main butter-fat producing area of the State.

The climate of the region is mediterranean in type, with warm dry summers and high and reliable rainfall during cool winter months. The growing season, in which the average rainfall exceeds the effective rainfall, varies from 6.7 to 10.3 months per year throughout the region. The natural vegetation consists mostly of heavy forest, making clearing and pasture establishment a lengthy, laborious and costly procedure. The soils are of low inherent fertility, having an extremely low phosphate status and in parts of the area they are also acutely copper deficient and zinc deficient. The pasture species are almost entirely annuals, particularly subterranean clover which is dominant and normally grows for only 6½ to 8 months of the year.

Developed farms do little better than carry one cow unit per 4-5 acres of pasture and, except in a few herds, are milked for only about seven months of the year.

A full report on the survey may be published by the writer elsewhere but some of the findings, relevant to the present discussion, are presented here, together with appropriate comment.

These facts are presented in three sections:

(i) those concerned with management practices, to give an indication of the extent to which farmers in the region surveyed had or had not incorporated a number of recommended and approved productive practices into the management of their farms.

(ii) those concerned with economic and financial considerations of the farmers.

(iii) personal details of the farmers.

Management Practices

(*a*) 55 per cent. of farmers did not harrow any pasture.

(*b*) 62 per cent. did not grow autumn green-feed.

(c) 36 per cent. hand-stripped.

(*d*) 53 per cent. dried off their herds more than three months prior to calving.

(*e*) 44 per cent. did not inoculate against contagious abortion with Strain 19 vaccine.

(*f*) 29 per cent. bought bulls without a knowledge of the bull's butter-fat backing, or the vendor's herd average.

(*g*) 21 per cent. had bulls running with the herd all the year round.

(*h*) an average of only about 50 per cent. of the recommended amount of fodder, mostly subterranean clover and brome grass hay, per cow was conserved, even by those farmers who entered the Better Dairying Competition in 1951-52. Considerably less than this was conserved by many farmers.

These examples indicate obvious room for improvement in management within the intensive margin. Furthermore, the adoption of some of the recommended

practices involves no additional cost to the farmer and may indeed result in reduced labour time and expenses per unit of output.

The only satisfactory explanation of the above situation, is either ignorance by the farmers of these various costless and profitable ways of increasing the efficiency of their existing resources, or apathy. Ignorance appears a better explanation than apathy, in view of the opportunities which exist for reducing the amount of work and money expenses.

Expansion of output within the intensive margin may also be brought about by the application of more capital equipment to the present effective land area by the existing labour force. This is particularly the case on farms infested with Bracken Fern (*Pteridium aquilinum*). The only satisfactory and practicable control measure, so far known, is several mowings per year. This is seldom done often enough without a tractor and yet only 45 per cent. of the farmers possessed one. As a result the quality of pastures on many farms is deteriorating. The possession of a tractor seems necessary to prevent this, though it would necessitate a larger effective farm size to avoid over-capitalization. It would also facilitate the "cleaning up" of pastures which are constantly menaced by falling timber in these areas, would enable the more effective timing of many operations and the accomplishment of more work per unit of labour time.

Economic and Financial Data

(*a*) 20 per cent. of farmers had less than 15 dairy cows which calved in 1951.

The labour force on many farms is thus relatively under-employed. As the labour unit on most of these farms is indivisible, expansion of farm area is the obvious source of increased production. This involves a consideration of opportunities at the extensive margin.

(*b*) The average farm area was 374 acres of which only 167 acres were cleared or part cleared. The undeveloped portion was, in most cases, considered to be capable of development to pasture of the same standard as that already existing on the rest of the farm. Evidently, therefore, there is great scope for increasing the effective area per farm and per unit of labour.

(c) 30 per cent. of farmers did not sow any pasture on new land for the first time during the three years ending in 1952. The average area of such pasture sown per year during these years by all farmers surveyed was actually 8 acres. The median area was only 5 acres.

(*d*) There was a highly significant tendency for farmers with greater indebtedness to develop a larger area during each of the previous three years.

(*e*) There was a significant association between more cows per man and more development.

In other words, insofar as cows per man is an index of how much work (other than development) which dairy farmers perform, then, in these instances, too much other work can hardly be advanced as the real reason for the slow rate of development.

(*f*) There was a highly significant positive correlation between development and nett farm income.

This indicates that the more well-to-do farmers were developing their farms at a faster rate than the poorer farmers.

(*g*) There was a significant inverse relationship between the age of the farmer and the extent of farm development.

In other words, there was a tendency for less development to be undertaken by the older farmers.

In bringing these single relationships (d, e, f, and g) together it is found that 28 per cent. of the farmers had negligible indebtedness (liabilities of up to only 10 per cent. of farm assets). Of these, only 41 per cent. had developed an average of more than 3 acres of new pasture per year during the three years ending in 1952.

Of the 59 per cent. who had developed 3 acres or less, 23 per cent. were under 55 years of age, milked less than 20 cows and had a nett farm income lower than the median of income of £530. Thus 23 per cent. of farmers who had negligible indebtedness, appeared to have the youth and labour time for a rate of development greater than 3 acres per annum. *They also had low incomes, which they apparently considered to be too low for the current terms of borrowing for development to be sufficiently attractive.*

(*h*) There were 40 farmers with more than the median nett farm income of £530 per annum. Nine of these who were under 55 years of age, milked less than 25 cows per man and had liabilities of less than 30 per cent. of assets, developed an average of less than 10 acres of new pasture per year. *Thus 22 per cent. of farmers with adequate incomes for borrowing appeared to have the age, labour time and credit resources to expand at a rate faster than 10 acres per annum.*

The only reasonable explanation of their failure to do so appears to be an unwillingness to borrow or to exert themselves further.

The facts presented indicate that inadequate knowledge prevents many farmers from achieving a higher output at the intensive margin and that inadequate income and unwillingness to borrow prevent many farmers from achieving a higher output at both the intensive and extensive margins.

Personal Details of Farmers

(*a*) A large proportion of the farmers were relative newcomers to their farms. 41.5 per cent. were in occupation for up to only 5 years and 55.2 per cent. up to 10 years.

(*b*) 36 per cent. had been working on farms all their working lives; 29 per cent. had been unskilled manual workers before taking up their farms; 15 per cent. semi-skilled and lower "white-collar" workers and 20 per cent. other and unclassifiable.

(*c*) Most had only a minimum of schooling. 74 *per cent. left school at age* 14, *on average* 30 *years ago.*

(*d*) Few read books of any sort. 55 per cent. did not get the free Journal of the Department of Agriculture in 1951. 33 per cent. had a book on dairy-farming and only an occasional farmer possessed a dozen or so books of any kind.

These facts are suggestive of serious limitations of the written medium of extension. For such people personal contact with the agricultural adviser is clearly the most likely effective way of closing the present wide gap between recommendation and practice.

Discussion

The above facts and inferences contain far-reaching implications for policy-makers in their attempts to increase the volume of agricultural production from the existing agricultural labour force.

To what extent these facts, obtained from only a small and relatively backward and pioneering fraction of Australian farming, apply to the rest of Australian agriculture, is unknown because similar data for these other areas are almost non-existent. The facts obtained in this survey, however, point clearly in two directions to which policy must be directed to effect rapid improvement. They are agricultural extension and agricultural credit.

Extension

Agricultural extension is a seriously neglected field of research in Australia. Extension workers and their administrative chiefs should know something of the background of the people whom it is intended to advise and help. The importance of this is revealed by the personal details of farmers presented in the preceding section. It is apparent that the written medium of extension is largely wasted on such people and that more personal contact with visiting advisers is likely to be much more beneficial.

Another neglected field of study important for agricultural extension, is the areas of knowledge in various regions and industries upon which extension resources should concentrate. Farm surveys designed for this specific purpose may be particularly useful. There is a tendency to think that unless there is a specific farming problem, or unless there is some new finding from research, there is no need for extension. The short list of practices already given should dispel these notions.

Farm surveys also indicate the need for extension workers to enter into the field of farm organization and management. This farm management approach which is in sharp contrast to the partial and technical approach of most present day extension is needed by many farmers throughout Australia. It may even be a means of breaking down the unwillingness of many farmers to borrow, thereby increasing output. At the present time the farm is largely thought of as a place on which there may be an odd technical problem or two. In extension in Australia, the farm has not yet become a technical, economic, and social unit, in which every technical problem is almost inextricably related to other technical aspects of the farm, and to finance, and to the family group. Consequently, the farmer gets no assistance in farm organization, farm management, and with financial and labour problems. Assistance is almost limited to the answering of specific questions asked by the farmers.

Credit

In relation to agricultural credit the survey indicates that some apparently creditworthy farmers appear not to be availing themselves of credit facilities to the extent which the condition of their farms would suggest was necessary. For this, two reasons have been put forward; inadequate income, and among those who may be considered as having adequate income, an unwillingness to borrow.

For the low income farmers the remedy lies in special credit facilities and credit supervision. These in effect would amount to a subsidization of a low income and relatively unproductive group of farmers. *This could be a more effective method of assistance to, say, dairy farmers, than by increasing prices of dairy produce.* Such a form of assistance would help only those in need. It could be also a part solution of low productivity by directing credit to productive avenues of farm investment, which, once made, become self-supporting. In the event of such assistance being made available, special conditions may be required to avoid trafficking in the capitalized benefits thus conferred.

For farmers not handicapped by "excessively" low income and who appear to be unwilling to borrow for development, a different policy appears to be appropriate.

In the first instance it must be pointed out that so far no exhaustive study has been published in Australia, elucidating factors influencing farmer demand for credit. The more commonly advanced opinions seem to favour the next slump, high costs, material shortages and inadequate labour as the main reasons for many farmers with relatively under-developed farms not borrowing for development. Until facts can be obtained, it seems justifiable to assume that risk and uncertainty of the future loom large in the frame of reference of many farmers.

As a partial remedy, it is suggested that part of a revised credit policy be to inform farmers of future local and world needs, world-wide trends in investment and employment and consumption, of the implications of full employment policies and development of underdeveloped countries, of local price policies and so on. This type of action, it is suggested, is necessary to help many farmers overcome the "next slump" complex.

Insofar as the other reasons offered are significant, they are aspects rather of the whole national economy and cannot be appropriately dealt with here.

Another aspect of unwillingness to borrow is that many farmers are simply not aware of profitable investment opportunities on their own farms. This unawareness arises out of inadequate technical knowledge, and out of an inability to assess the likely financial outcome of many innovations and further development. This too, provides a strong case for the farm management approach in extension and credit administration, and also for the employment by advisory and lending institutions of more suitably and highly trained agriculturalists.

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TECHNICAL PAPERS

LATHYRUS OCHRUS (L.) DC. as a GREEN MANURE UNDER IRRIGATION IN THE MURRAY VALLEY AREA

By J. E. GILES, C. A. NEAL-SMITH and D. McE. ALEXANDER

Summary

Lathyrus ochrus, an annual legume introduced from Israel, has been shown to be a valuable irrigated green manure species on a wide range of soils in the Murray Valley area. It outyielded other commonly grown green manure species on all the lighter soil types over two seasons (1950 and 1951) and equalled tick beans on some of the heavier soils. Nodulation of *L. ochrus* was satisfactory on all soil types and the nitrogen content of the herbage was similar to that of other leguminous manures.

L. ochrus is of particular value because of its relatively rapid growth rate, earliness of maturity and high yield of nitrogen at the time of turning under. This enables the burying of the crop by early spring and minimises the risk of frost damage to horticultural plants, particularly vines, which may occur if a green manure crop is left standing at this time.

On a Barmera sand, one of the major soil types of the Mildura district, April sowing with controlled spacing, 7 in. by 4 in. (a seed rate of 60 lb. per acre) gave satisfactory yields of herbage and seed.

Introduction

In Murray Valley settlements there are approximately 80,000 ac. under irrigation for the production of horticultural crops. The climate of the area is mainly of the Mediterranean type with moderate winter rainfall and summer drought with high temperatures which are essential for the ripening and effective drying of the fruit. The rainfall of Mildura over the months April to August averages about 5 in. while the mean daily maximum and minimum temperatures are 65° and 44.5°F. respectively. Data for the same period for Woorinen are rainfall 6.5 in., mean daily maximum and minimum temperatures 63.3° and 42.5°F. For horticultural production it is essential to supplement the seasonal rainfall by irrigation.

The growing of winter green manure crops has become established as a regular part of the cultural operations involved in horticultural production. While the effects of green manuring are not yet fully understood, the importance of the maintenance of organic matter in relation to economic yields of horticultural crops has been widely recognised (West and Howard, 1938, Madson, 1951).

The species commonly utilized are tick beans (*Vicia faba* L. var. *minor* Beck.), field peas (*Pisum arvense* L.), tares (*Vicia sativa* L.) and barley (*Hordeum vulgare* L.). Of these, tick bean is most widely grown. However, this crop is relatively unproductive on all soil types in certain seasons and on some of the lighter soil types in all seasons. Tick bean seed is imported to the area at considerable cost and in some years supplies have been insufficient. For these reasons, investigations were made to determine whether other species not previously grown in the area would prove superior. From preliminary investigations conducted at Can-

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berra, Griffith and Merbein on four species, namely, *Lathyrus ochrus* (L.) DC., *L. tingitanus* L., *Vicia articulata* Hornem., and *Vicia dasycarpa* Tenore., *L. ochrus* was selected for further trial because of its early maturity, comparatively high yield and ease of seed production.

In a subsequent replicated single row trial at Red Cliffs involving *L. ochrus* L., *L. clymenum* L., *L. cicera* L., and another strain of *L. cicera* (introduced as *L. arvensis*), *L. ochrus* was again outstanding (yields in cwt./ac. dry matter were 59.1, 30.1, 28.2 and 22.6 respectively).

L. ochrus (Figure 1) is an annual, winter growing legume of an essentially spreading growth habit. In a dense stand, however, the branches, which arise at ground level, become more or less erect and may attain a height of 2 ft. or more. The plant has a densely leafy appearance and is of a light green colour. It has a relatively short growing season and the pods, which are about 2 in. long, retain their seed after maturity. The species is indigenous to the Mediterranean region including Palestine, Spain and Cyprus, and in the latter two countries it is known as Louvana. Other common names used are Cyprus Vetch, Pigeon Pea, Ochrous Pea and Yellow Pea. The particular strain used in the trials was introduced by the Plant Introduction Section of the C.S.I.R.O., Canberra in 1945.

Experimental Procedure and Results

Because of considerable variation in moisture content of herbage between sites, all herbage yields and nitrogen percentages are expressed on the oven dry basis.

Yields were obtained by cutting samples each 5 ft. along the row or plot by the full width of the growth. These were

Figure 1.
Development of Lathyrus ochrus four months from sowing on Barmera sand, Red Cliffs, September, 1951.

weighed and a 2 lb. sub-sample taken from each. For the trials described under (b) and (c) moisture determinations were done on every sub-sample. For the trials described under (a) eight sub-samples were bulked to give a 16 lb. sample for moisture determination. All moisture contents were determined by oven drying at 85°C. Herbage yields were then adjusted to the oven dry basis.

(*a*) *Studies in the growth habit and herbage production of L. ochrus grown on various soil types.*

To study the growth habit, herbage production and nitrogen content of *L. ochrus* under field conditions, in comparison with a control green manure crop, soils ranging from very light to heavy were selected for trials on growers' properties. Cultural practices, such as number of irrigations, amounts of fertilizer applied, time and method of sowing differed from property to property, but similar cultural treatments were observed within each property for both the *L. ochrus* and the particular control species used.

The results, given in Table I, show that the dry weight herbage yields of all species are in general markedly less on the lighter soils, namely Murray sand, Berri sand and Barmera sand. On these soils, *L. ochrus* had a mean yield of 32 cwt./ac. compared with 44 cwt./ac. on the heavier ones. For other species comparative figures are 22 and 48 cwt./ac. respectively.

On the sand soils, *L. ochrus* outyielded the control species in all cases, the overall mean increase being 32 per cent. On the heavier soils it outyielded peas or tares, but when compared with tick beans, the advantage was most often in favour of the latter. Peas were relatively unproductive on each of the soils on which they were grown. The particularly poor growth of both peas and *L. ochrus* at Location 11, Irymple loam, was associated with the fact that the green manures were not irrigated on this site.

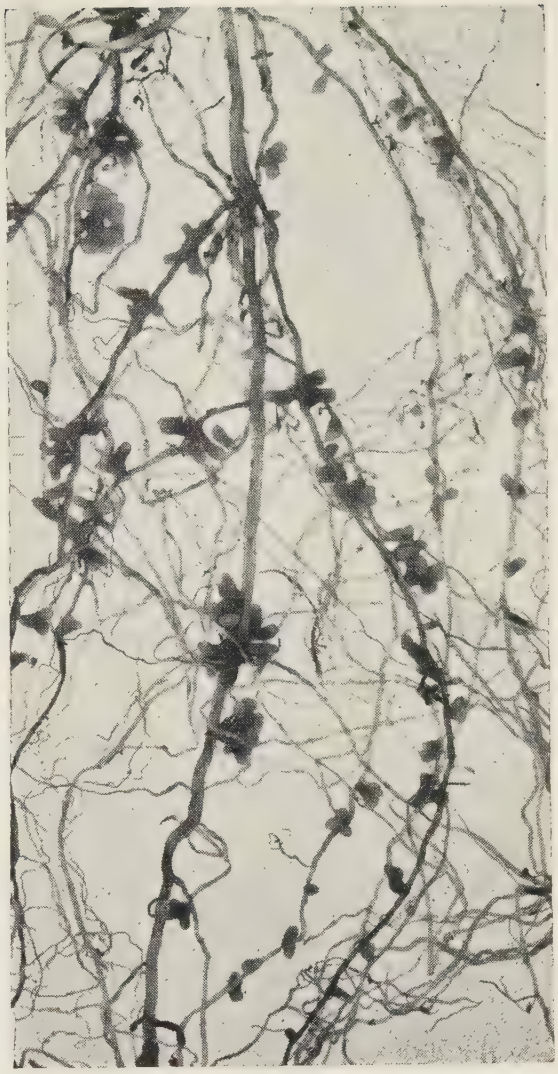

Figure 2.
Portion of the root system of a Lathyrus ochrus plant showing strong and effective nodulation.

L. ochrus has thus been shown to be particularly adapted to soils of a light texture and to outyield the standard species by 10 cwt. of dry matter per ac. on three of these soils. It was found to be uniformly well nodulated at every site and on every plant examined (Figure 2).

(*b*) *Seeding rate and time of sowing of L. ochrus and tick beans.*

To determine the effect of varying seeding rates and times of sowing for both

TABLE I

Yield and nitrogen content of dry herbage of L. ochrus and control crops grown in 1950 and 1951 seasons on various soil types listed in order of texture

Location	Soil Type*	Year of trial	L.OCHRUS		CONTROL		
			Dry wt. cwt./ac.	%N.	Species	Dry wt. cwt./ac.	%N.
1. Red Cliffs	Murray sand	1950	22	2.99	Peas and barley	17	3.20
		1951	36		Beans, peas and barley	23	
2. Red Cliffs	Barmera sand	1950	29	2.81	Beans	13	2.10
		1951	33		Tares and barley	29	
	Berri sand	1951	36		Tares and barley	26	
3. Irymple	Barmera sand	1951	33	2.28	Beans	22	2.65
4. Merbein	Barmera sandy loam (shallow phase)	1950	21	not determined	Beans	43	2.91
5. Merbein	Coomealla sandy loam	1950	32	2.94	Beans	15	2.99
					Tares	23	3.51
		1951	75		Beans	106	
					Tares	53	
6. Woorinen	Tatchera sandy loam (Type 8)	1950	31	not determined	Beans	56	not determined
7. Merbein	Coomealla loam	1951	47	2.68	Beans	40	1.72
8. Mildura	Koorlong loam	1951	71	2.68	Beans	67	1.91
9. Irymple	Mildura loam	1950	24	3.41	Beans	40	2.81
10. Mildura	Mildura loam	1950	44	3.19	Beans	62	2.97
		1951	62	2.57	Beans	92	2.52
					Peas	20	3.33
11. Irymple	Irymple loam	1950	18	2.12	Peas	12	2.39
12. Woorinen	Woorinen loam (Type 7)	1950	57	3.32	Beans	46	2.57

*All soil types, with the exception of the Woorinen ones, are described by Penman *et al.* (1940). Of the Woorinen types, Tatchera sandy loam (type 8) was named by Taylor *et al.* (1933) and Woorinen loam (type 7) named by Prescott and Taylor (1932).

L. ochrus and tick beans, a trial which consisted of randomised blocks with six replications of each species was conducted in 1951 at Red Cliffs, Victoria, on Barmera sand.

The seeding rates were 90, 135 and 180 lb. per ac. for *L. ochrus* (germination 95.7 per cent.) and 120, 180 and 240 lb. per ac. for tick beans (germination 100 per cent.). The two dates of sowing were April 11 and May 15, 1951. Each plot consisted of 9 rows spaced 7 in. apart, giving an area 10 ft. by 5 ft. 3 in. The centre row was left unsown. Superphosphate at the rate of 3 cwt. per ac. was applied at sowing and adequate soil moisture was maintained throughout the growing period by the natural rainfall except that plots sown on April 11 were irrigated immediately after sowing.

The results (Table II) clearly indicate that at the sampling date (September 12), April sown crops outyielded the May sown ones in both species. It was observed in other field trials that good results were also obtained when the sowing was made in March.

For *L. ochrus* a seeding rate of 135 lb. per ac. appeared the best for both times of sowing, since a crop with this seeding rate outyielded the one seeded at 90 lb. per ac. and was as productive as the one seeded at the rate of 180 lb. per ac. In tick beans, yields from the April sowing were highest with a sowing rate of 180 lb. per ac., while for the May sowing, the highest yield resulted from a sowing rate of 240 lb. per ac. Thus it appears that the reduced yield associated with the later sowing may in part be compensated for in this crop by increasing the seeding rate.

The yield of *L. ochrus* was higher than that of tick beans at each corresponding

TABLE II

Dry weight yields of L. ochrus and of tick beans with varying seeding rates and times of sowing on a Barmera sand, 1951 season

Species	Seeding Rate lb./ac.	Sowing Time	
		April 11	May 15
		Dry weight cwt./ac.	Dry weight cwt./ac.
L. ochrus	90	78.7	49.8
,, ,,	135	87.6	58.1
,, ,,	180	86.5	56.9
Tick beans	120	62.7	36.9
,, ,,	180	80.2	40.6
,, ,,	240	75.9	48.2

Treatment means not significant for the April sowing.

Min. difference for significance between treatment means for both species, May sowing ($P<0.05$), 6.6.

TABLE III

Dry weight yields of herbage in cwt./ac. and yield of seed in lb./ac. of L. ochrus with varying seeding rates and seed spacings, Barmera sand, 1952

Treatment	Number of rows sown	Seed spacing in.	Row spacing in.	Rate of seeding (lb./ac.)	Yield of herbage (cwt./ac.)	Yield of seed (lb./ac.)
1	2	2	28	29.25	39.1	2471
2	4	2	14	58.5	52.5	2973
3	8	2	7	117.0	63.0	3260
4	8	4	7	58.5	61.0	2894

Least difference for significance in herbage yield: ($P < 0.05$) 3.7 cwt.
Least difference for significance in seed yield: ($P < 0.05$) 404 lb.

seed rate at both times of sowing, and although not significantly greater in all cases, the effect was consistent.

(*c*) *Herbage and seed production in relation to seeding rate and seed spacing.*

A further trial to determine the best seeding rate in relation to seed spacing of *L. ochrus* for the production of herbage and of seed was conducted on the same site at Red Cliffs in 1952. The design was a duplicated Latin square in each section and the trial consisted of two sections, one to determine herbage production and the other seed yield. The plot size was 10 ft. by 5 ft. 3 in. The rows were spaced 7, 14 and 28 in. with seed spacing 2 or 4 in. within the rows according to the seeding rate (Table III). Superphosphate at the rate of 2 cwt. per ac. was applied to all plots at sowing.

The trial was sown on April 19, 1952, and sampled for herbage yield on September 9, and for seed yield on October 22. Plant establishment was very good on all plots with a mean over both sections of 90 per cent. of sown seed in treatments 1, 2 and 4 and a mean of 84 per cent. of sown seed in Treatment 3. The sowing details, together with the dry weight of herbage and yield of seed are given in Table III.

Table III shows that the highest yields of herbage and of seed were obtained with a 7-in. spacing between rows with seed sown 2 in. apart in the row. No significant reduction, however, in the yield of either herbage or of seed resulted when the seeding rate was halved by sowing seed 4 in. instead of 2 in. apart at the same row spacing. The indications are that a controlled 7 in. by 4 in. spacing (60 lb. per ac.) may be adequate for near maximum yields of both herbage and seed on a Barmera sand.

(*d*) *Yield and nitrogen content of roots and shoots in relation to maturity.*

An investigation to determine the dry weight and total nitrogen content of roots and shoots at various stages of maturity of *L. ochrus*, tick beans and tares was conducted in the 1950 season at the Commonwealth Research Station, Merbein, on a Coomealla sandy loam soil.

To determine the root: shoot ratio, yields of roots and shoots were measured on eight individual plants of each species grown in galvanised iron pipes 2 ft. long by 9 in. diameter buried in various posi-

tions along a vine row. The pipes were placed in holes excavated with a 10-in. soil auger and soil back filled in reverse order so that the profile remained similar to field conditions. A single plant was established in each pipe from seed sown on April 12, and subsequently required no special attention. At maturity, the pipes were completely excavated and the soil washed from the bottom upwards so as to leave the roots exposed. Roots and corresponding shoots were dried at 55°C. and the dry weight recorded. Nitrogen analyses were made by the Kjeldahl method on the roots and shoots of each of the individual plants. Root yields of the plants harvested at various stages of maturity have been estimated by using a root: shoot ratio of 0.5 which was found for each of the three species by the technique described immediately above.

On the basis of this root: shoot ratio of 0.5, the total dry weight yield and nitrogen content of roots plus shoots of *L. ochrus*, tick beans and tares grown on Coomealla sandy loam in 1950 (Table I, Location 5) have been calculated for two times of sampling in each species. The results given in Table IV show that *L. ochrus* had a higher yield (47 cwt. per ac.) on September 12, 1950, than either tick beans or tares which yielded 23 and 36 cwt. per ac. respectively. Although on October 9 (nearly one month later) the yield of beans (73 cwt. per ac.) and of tares (63 cwt. per ac.) was higher than that of *L. ochrus* a month earlier, this date is considered too late for practical purposes.

At August 30, the yield of *L. ochrus* (34 cwt. per ac.) was considerably greater than that of tick beans (23 cwt. per ac.) on September 12, and almost equal to that of tares (36 cwt. per ac.) at the same date.

In common with other crops, the nitrogen percentage of the shoots of the three species diminished with the maturity of

TABLE IV

Yield and nitrogen content of green manure crops grown at the Commonwealth Research Station, Merbein, 1950

Species	Sampling date	Dry weight yield of roots plus shoots cwt./ac.	% Nitrogen		Total nitrogen of roots and shoots lb./ac.	Maturity rating*
			Roots	Shoots		
L. ochrus	30/8/50	34	—	3.38	118	3
	12/9/50	47	2.20	2.94	127	4
Tick beans	12/9/50	23	—	2.99	77	2
	9/10/50	63	2.32	2.50	173	3
Tares	12/9/50	36	—	3.51	130	1
	9/10/50	63	2.25	2.84	186	2

*Maturity rating—1. Pre-flowering.
2. First flowers, no pods.
3. Full flower, first pods fully formed.
4. Considerable pod formation.

the plants. The relatively high nitrogen content of tares at September 12 is a reflection of its immaturity.

L. ochrus had a higher nitrogen content than tick beans and tares at a similar stage of maturity. At a comparable stage of maturity (full flower and with first pods fully formed) *L. ochrus* had a nitrogen percentage of 3.38 compared with tick beans 2.50. Had tares been grown to this stage of maturity, their nitrogen percentage would have been less that 2.84 per cent.

The total nitrogen yield, estimated from the product of yield and nitrogen percentage, in *L. ochrus* and tares at September 12, 1950, is essentially the same, but that of tick beans was comparatively lower. The wide variation in yield masked the variation of nitrogen percentage so that, although the nitrogen percentage varied between species there was a close correlation between total dry yields and total yield of nitrogen.

Similar results were obtained on eleven other sites where the mean shoot nitrogen content was 2.70 per cent., with standard deviation 0.21 per cent. (Table I).

Discussion

The trials described above indicate that *L. ochrus* has several advantages over legumes commonly used as green manures under irrigated conditions in the Murray Valley area, particularly in view of the desirability for early ploughing in of such crops.

On the sands where cover crops in general yield comparatively poorly, *L. ochrus* has outyielded the particular control species in every case. Higher yields were obtained on the heavier soils, but on these soils tick beans yielded as well or, in some cases, better than *L. ochrus*.

It is recognised in viticultural practice in Murray Valley areas that leguminous cover crops should be ploughed or disced down at the early flowering stage, preferably by the middle of September, to prevent competition for soil moisture and plant nutrients and to minimise possible frost damage in some areas. King (1948) has stated that there is ample confirmation of frost damage to vines due to standing cover crops and these should be buried before the danger period. A particular advantage of *L. ochrus* is its early maturity which allows the maximum amount of herbage to be buried by about the first week in September, thus reducing the risk of possible frost damage to the young tender vine shoots.

No difficulty was observed in obtaining satisfactory plant establishment under varying cultural treatments and the large number of nodules evident in every case is indicative of the presence of a suitable strain of *Rhizobium* in the soils of the area.

Seeding rates of *L. ochrus* are commonly of the order of 125 lb. per ac. (Hurwitz, 1940). April sowings at about this rate on Barmera sand in 1951 and 1952 gave the highest yields of herbage, but in the second year it was demonstrated that near maximum yields of herbage and of seed could be obtained from a sowing of about 60 lb. per ac. by spacing seeds 4 in. apart in the rows. Clearly there is need for further investigation to determine how far these findings could be applied to other soil types and cultural methods. If seed yields of nearly 3,000 lbs. per ac. from sowing of about 60 lb. per acre can be reproduced, seed production in the Murray Valley would be a satisfactory commercial proposition, even allowing for a small percentage loss due to machine harvesting by means of a pea header. So far seed production has been done mainly without any special equipment by growers who have sown *L. ochrus* between vine rows.

The yields of the May sown *L. ochrus* and tick beans were considerably less than the April sown treatment, but the yield reduction in *L. ochrus* (34 per cent.) due

to late sowing was less than that for tick beans (40 per cent.). This may make *L. ochrus* more suitable when circumstances necessitate a late sowing of the cover crop.

In every sample of *L. ochrus* analysed the nitrogen content was greater than 2 per cent. A few samples of tick beans gave a nitrogen percentage below 2 per cent. (down to 1.72) but, in general, these also were above this figure. Bachelor (1943) has stated that the critical nitrogen content of a green manure crop is 2 per cent. Above this figure, the following crop benefits, while below it the nitrogen is absorbed entirely by the micro-organisms effecting decomposition and this may even cause a temporary immobilisation of existing nitrogen supplies.

An application of 2 cwt. per ac. of sulphate of ammonia is often made where tick beans have been grown for green manure in order to overcome the relatively slow rate at which nitrogen becomes available from their decomposition. The less fibrous growth habit of *L. ochrus* suggests that it may decompose more rapidly in the soil. This, combined with its earlier maturity, might result in a substantial economic gain by rendering the application of sulphate of ammonia unnecessary.

The adaptability of *L. ochrus* to light-textured soils and its higher yields from earlier plantings are in accordance with the findings of Hurwitz (1940) in Israel. In that country *L. ochrus* is grown for fodder purposes and is one of the few productive species on light soils. On heavier soils in Israel its yield was higher, but other species proved equally or more productive.

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The authors desire to express their appreciation to all the growers who collaborated with them by conducting trials on their properties. The authors are particularly indebted to Mr. E. A. Lawton, who was responsible for the photography and to Mr. G. A. McIntyre for advice concerning the design of the trials and for conducting the statistical analyses.

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CONTROL OF RAGWORT BY HORMONE-TYPE WEEDICIDES

By I. McL. EADIE and B. D. ROBINSON

Summary

The characteristics and control of Ragwort are discussed.

A trial was made using the ethyl ester of 2:4-D, butyl ester of 2:4:5-T, butyl ester of MCP and mixed butyl and ethyl esters of 2:4:5-T and 2:4-D applied as semi-high volume sprays to seedling and rosette Ragwort at 1, 2 and 4 lbs. of acid equivalent per acre. The ethyl ester of 2:4-D gave the best control and is therefore recommended for the economical control of young Ragwort at the 2 lb. rate. Applied at this rate, ester 2:4-D is approximately five times cheaper to apply than chlorates or arsenicals and the value of the treated pasture considerably higher.

To eradicate Ragwort ester 2:4-D sprays must be applied to all infested areas over a number of years.

Where spraying is delayed, application of the quick-killing chlorates and arsenicals is desirable to prevent seed setting of more mature Ragwort.

T.C.A. cannot be recommended for the control of Ragwort.

Figure 1.
Heavy infestation in Gippsland where Ragwort is continuing to grow regardless of cultivation.

Introduction

Ragwort (*Senecio Jacobaea*) is a tenacious perennial or biennial plant which, besides being a bad weed in New Zealand, Tasmania, Canada and Ireland, is a declared noxious weed in Victoria, New South Wales, Western Australia and part of Queensland. Ragwort grows profusely in the high rainfall areas of Gippsland and the Otway Ranges, and flourishes in dairying pastures as cattle will not eat it unless forced to do so by lack of other food.

Experience has shown that the spread of Ragwort has been assisted by land owners attempting to clear more land than they can maintain or bring under production. Unless cleared or burnt areas are worked and brought into production, they become seed beds for Ragwort which soon infests the whole area. Ploughing, unless followed by frequent cultivations, will create ideal conditions for the growth of Ragwort (Figure 1). Where ploughing has been followed with four summer cultivations good control of Ragwort has been obtained. Many farmers who, either through neglect or ignorance of the dangers of this weed, have failed to keep it in check have found that their farms have been overrun within a few years, resulting in enforced abandonment.

Besides taking up useful space in pastures, Ragwort is poisonous to cattle. It is thought that alkaloids present in the plant, possibly in both the green and dry state, are responsible for the fatal toxic

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effect. Ragwort poisoning has been observed in Victoria, New Zealand and Ireland.

Ragwort seeds can be spread by animals, wind, water and vehicles, etc. It has been shown that seeds will pass through sheep and germinate in their droppings. Ragwort seeds may also be carried to clean areas in potato bags, and produce taken from infested areas. It can be propagated from cuttings taken off either the roots or the crown. Unless all of the crown and root system is killed by spraying, ploughing or pulling, the plant will regenerate from remaining pieces of crown or root.

Methods of Control

Sheep are used to check Ragwort on large areas where it has become so thick that other means of eradication are uneconomical. Sheep will develop a taste for Ragwort after a period under adverse conditions and seem to show a preference for the young flower heads of Ragwort. In New Zealand it has been found that Ragwort poisoning in sheep is cumulative and that it is advisable to "spell" them on clean areas to keep them in good health. The use of sheep can only be regarded as a temporary expedient to keep Ragwort in check so that a more intensive effort, applied to a long-range plan of eradication by cropping and/or pasture improvement, can be carried out.

Other methods used in keeping Ragwort in check are chipping or "spudding" the plants, which is relatively ineffective, as this causes new shoots to form from the remaining roots and crowns. Cutting when the seed first starts to set (when the flowers burn brown) kills some plants *but* is not a safe or practicable method of eradication unless all flowering heads are gathered up and burnt.

Ragwort can be killed where only a few rosette plants occur, by crushing the crown of the plant with the heel of the boot and placing a small handful of salt on the crushed surface. Alternatively, Sodium Chlorate or "Atlacide" Powder used in the same manner, is generally more effective.

Sprays containing Sodium Chlorate are effective against Ragwort since the chemical is absorbed by the leaves and translocated to the roots. Sodium Chlorate is non-toxic to stock but is *dangerous* to use as it is explosive and highly inflammable. "Atlacide" is a commercial weedkiller containing Sodium Chlorate which has calcium chloride added to it to eliminate the dangers inherent with the use of pure Sodium Chlorate. This material is used at the rate of 1 lb. per gallon of water.

Weedicides containing arsenic, although poisonous to stock and operators, may be used to good advantage if carefully and properly applied and stock are kept off treated areas for 14-21 days or until heavy rain has fallen. Care should be exercised to see that spray mixture does not fall or soak into pools or drinking water. The addition of phenyl to arsenical spray mixtures makes the sprayed areas less attractive to stock.

Arsenic Pentoxide is used at the rate of 1 gal. to 29 gal. of water and sodium arsenite (soluble arsenite of soda) at the rate of 1 lb. to 10 gal. of water. Sprays containing chlorate or arsenicals are generally applied at 100-200 gal. per acre.

Hormone-type weedicides have shown promise for the control of Ragwort in overseas trials, but the results of small-scale trials in Victoria have been too variable to make definite recommendations. It is apparent that seasonal conditions and other factors, such as stage of weed growth, affect the degree of control using these types of weedicides.

To further determine the value of these preparations for the control of this plant various esters of MCP, 2:4-D, 2:4:5-T and mixtures of 2:4-D/2:4:5-T were selected for trial, since these are regarded

as being more active on an acid equivalent basis than the sodium and amine salts. Further, the esters, which are oil soluble and formulated as water miscible oils, adhere more readily to foliage than the water soluble amine and sodium salts which are more easily removed by rain. Most of the Ragwort in Victoria grows in high rainfall areas where it is necessary for farmers to use formulations which are not readily affected by adverse spraying conditions.

Trial Procedure

The trial area, near Foster, was selected because the infestation was particularly heavy (up to four Ragwort plants per square link) ; the plants growing under favourable conditions on a red loamy clay. The infestation was even and treatment made when the weeds were in the seedling and rosette stages.

A knapsack sprayer with attached 4 ft. hand boom applied 40 gal. of spray per ac. through four flat fan monarch-type nozzles when the operator walked at 24 ft. per min. The operator travelled 1/40 ac. plots (200 x 12.5 lk.) up and back twice to apply the required volume of spray, and was guided by a centre string line knotted at 4 places so that he could be timed to cover the length of the plot in the correct number of seconds.

Each of the four treatments applied at the rate of 1, 2 and 4 lb. acid equivalent per ac., replicated 4 times, gave a total of 60 x 1/40 ac. plots, including 12 control plots. Each rate of application was randomised within the treatment and each treatment was randomised within the four replicates. Due to the nature of the trial area (a hill), the replicates were in pairs, 1 pair being on either side of the ridge which ran approximately east-west.

A wetting agent was added to all treatments at the rate of 3 fl. oz. per 40 gal. of spray. Spraying commenced at 5.30 a.m. on 22/11/51, when there was no wind. A slight dew did not increase run-off. The spraying of all treatments was completed by 12.45 p.m. on the same day so that all applications were made under relatively uniform conditions of temperature, humidity and light. No rain fell within 48 hours after spraying.

Assessment of the weed population before and after treatment was made by ten throws with a 5-sq. lk. quadrat along the length of each plot. Considerable difficulty was experienced in counting the Ragwort due to the similarity between seedling and suckering Ragwort plants. Fixed quadrats might be expected to give a more accurate determination of the population.

Results

Results of the trial, as assessed on 15/1/52, are summarised in Table I.

TABLE 1

Complete List of Means for Ragwort at Foster

Ester Percentage Kill	Concentration of Ester				
	0	1 lb.	2 lb.	4 lb.	mean
Ethyl 2:4–D		50.5	81.8	93.0	75
MCPA		40.6	31.0	85.7	52
Mixed 2:4-D/2:4:5-T		44.2	68.8	81.4	65
Butyl 2:4:5-T		–8.4	13.2	33.9	13
Control	–17.2				
Mean		32	49	73	
Difference required for significance between marginal means for esters at					
5% level					18
1% level					23

Figure 2.

Showing ester 2:4-D plots. 2 and 4 lb. acid equivalent applied per ac. Note untreated control plot on left and Ragwort between treated plots. Foreground treated with Atlacide to prevent seed contamination of plots.

These show that there is a highly significant linear increase in percentage kill with concentration of ester and that there is a significantly higher percentage kill with ethyl esters 2:4-D, MCP or mixed esters 2:4-D/2:4:5-T than with butyl ester 2:4:5-T.

Figure 2 gives a visual indication of the results obtained.

Discussion

The trial shows that a good percentage kill of young Ragwort can be obtained by applying 2 lb. acid equivalent per acre as the ester of 2:4-D or MCP. The ethyl ester of 2:4-D appears to be slightly more effective than butyl ester of MCPA, which may have been due to the lower volatility of the butyl ester as compared with the ethyl ester or the formulation, or that MCP is slightly less active against Ragwort than 2:4-D.

Since 2:4:5-T is a more expensive chemical than either 2:4-D or MCP, its use, either alone or in combination with 2:4-D, cannot be recommended.

The semi-low volume spraying (40 gal. of spray per ac.) gives adequate spray coverage and is of practical importance since most of the Ragwort in Victoria grows in hilly areas.

If Ragwort is treated in the seedling and rosette stages with the ester of 2:4-D at 2 lb. of acid equivalent per ac., good control can be expected for a cost for materials of approximately £2 per ac. It is, therefore, considerably cheaper to use hormone-type weedicides for control rather than chlorates or arsenicals which cost approximately £8 to £10 per ac. and require high volume spraying. The difference in pasture value is also significant. An inspection of all plots 18 months after treatment showed considerable seedling re-growth so that for complete control every Ragwort area would have to be treated on a front to prevent re-seeding and followed up with sprays

Figure 3.
Although showing severe hormonal effects due to late spray the plant is suckering at the base and death is incomplete.

in the next season to kill any survivors of the first spraying.

Ragwort plants, which had been sprayed after they had started to run up prior to flowering, grew on and set seed even though showing severe hormonal effects. Figure 3 shows typical suckering of Ragwort treated at too late a stage. Where spraying has been delayed for any reason it is necessary to treat Ragwort with chlorates or arsenicals to give a quick kill and prevent seed formation. Ragwort is becoming so extensive that it will be necessary to start spraying soon after germination of seeds and suckering of old plants commences during the winter, and continue with the treatment throughout the spring and early summer. Under good growing conditions Ragwort, treated in the young stages, took at least 8 weeks to die.

An investigational trial using TCA on Ragwort indicated that TCA applied at 50, 100, 150 and 200 lb. per ac. gave a good contact action only. Regrowth, following TCA treatment, is unusual in that the plants are stunted, the leaves are a darker green and more wrinkled than normal. TCA does not appear to be translocated through the leaves to the roots like chlorates and the non-destruction of roots allows TCA-treated Ragwort to sucker and flower profusely at a later date. Another investigational trial, using the ester, amine and sodium salts of 2:4-D applied as high volume sprays at 0.1 and 0.2 per cent. active ingredient to Ragwort in the flowering stage showed excellent eventual kills of the plants although control of seed setting was uncertain and further trials are contemplated.

Acknowledgments

The authors are indebted to Mr. E. J. Williams, of the Section of Mathematical Statistics, C.S.I.R.O., for assistance with the statistical analysis of experimental results, and to the Vermin and Noxious Weeds Branch of Victoria and to ICIANZ for the time and facilities needed to conduct the trial.

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PHOSPHORUS, SULPHUR AND MOLYBDENUM DEFICIENCIES ON SOME SOILS OF THE NORTHERN TERRITORY

By K. D. McLACHLAN

Introduction

Little is known of the nutrient requirements of the soils of Northern Australia. Recent surveys have shown that potentialities for agricultural development exist in the Northern Territory (Christian and Stewart, 1952).

Four soil types from Katherine, Northern Territory are examined in the present study. Stewart (unpublished data) has described and mapped the distribution of these soil types in the Katherine-Darwin region. The responses by a leguminous indicator plant, subterranean clover (*Trifolium subterraneum L.*), to phosphorus, sulphur and molybdenum are presented.

Experimental

The soils, which were surface samples, approximately 0-6 in. in each case, may be described as:—

Grey—a grey heavy clay soil of volcanic origin belonging to the Grey Soils of Heavy Texture—pH 8-8.5.

Red—a red clay loam of volcanic origin belonging to the stony Red Loams—pH 6.5.

Limestone—a red brown sandy clay loam, developed on Cambrian limestone, belonging to the Red Earths—pH 6.0.

Granitic—a grey coarse sandy soil, belonging to the Yellow Podzolics—pH 6.0.

On July 2, 1952, the pot culture experiment with these soils was commenced. Enamelled pots of $4\frac{5}{8}$ in. diameter were filled with 1.2, 1.1, 1.3, and 1.8 Kg., on an oven dry basis, of Grey, Red, Limestone, and Granitic soils respectively. The Bacchus Marsh strain of subterranean clover was used. The seed was inoculated with an effective strain of *Rhizobium* before sowing. Ten plants were grown in each pot in an unheated glasshouse.. The pots were weighed at frequent intervals and the soils watered to field capacity. The tops were harvested on October 23, 1952, oven dried and weighed.

In the experiment a randomized block design was used. There were five treatments, viz., nil, phosphorus plus sulphur plus molybdenum, phosphorus plus sulphur, phosphorus plus molybdenum, and sulphur plus molybdenum. Each treatment was replicated three times. The fertilizer dressings used were:—

sodium phosphate, 179 mgm/pot (P ≡ 3 cwt. superphosphate/ac.)

sodium sulphate, 456 mgm/pot (S ≡ 37.3 lb. sulphur/ac.)

sodium molybdate, 0.15 mgm/pot (≡ 2 oz. sodium molybdate/ac.).

All treatments were applied in solution. No basal dressing was used.

Results and Discussion

The effect of treatment on the yield of subterranean clover is shown in Table 1.

Significant responses to phosphorus were obtained on all four soils. The responses to sulphur were significant on all soils, except the one formed on granite. Significant responses to molybdenum were obtained on the Red and Granitic

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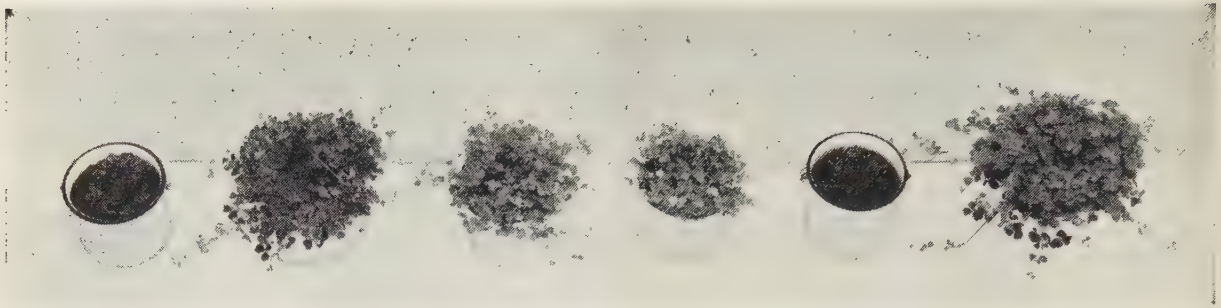

Figure 1.

Nil P+S+Mo P+S P+Mo S+Mo P+S+Mo at double rate.

soils. Figure 1 shows the effect of treatment on subterranean clover grown on the Red soil.

The percentage increase in mean yield due to treatment with one element in the presence of the other two is shown in Table II.

For three of the soil types, viz., Grey, Red and Limestone, sufficient soil was available to fill spare pots. These pots were randomized within the experiment and received dressings of phosphorus, sulphur and molybdenum at twice the rate set out above. This treatment gave a further increase in mean yield of 61.3 per cent., 29.4 per cent. and 37.8 per cent. for the three soils respectively.

The phosphorus deficiency on these soils was extremely severe. The percentage increase in mean yield due to treatment with phosphorus in the presence of sulphur and molybdenum was greater than that obtained with similar treatment on eastern Australian soils formed on similar parent material (McLachlan, unpublished data). The sulphur and molybdenum deficiencies recorded, were of the same order as those encountered on soils of Eastern Australia. Typical yellowing of the sulphur deficient plants was observed at an early stage.

TABLE 1.

Effect of treatment on the mean yield of subterranean clover

Treatment	gms. dry weight			
	Grey	Red	Limestone	Granitic
Nil	0.66 (0.81)*	0.93 (0.97)	1.00 (1.00)	0.55 (0.74)
P+S+Mo	12.03 (3.47)	11.90 (3.45)	13.43 (3.67)	5.37 (2.31)
P+S	10.40 (3.22)	8.23 (2.87)	13.07 (3.61)	2.70 (1.58)
P+Mo	5.90 (2.41)	5.53 (2.35)	11.70 (3.42)	4.53 (2.13)
S+Mo	0.53 (0.73)	1.23 (1.11)	1.03 (1.00)	0.55 (0.74)
Sig. diff. for $P < 0.05$	— (0.36)	— (0.21)	— (0.23)	— (0.62)
Sig. diff. for $P < 0.01$	— (0.52)	— (0.31)	— (0.34)	— (0.93)

**Figures in brackets are the square root transformations on which the statistical analysis was based.*

TABLE II.

Effect of treatment on the mean yield of subterranean clover

Treatment	Percentage increase			
	Grey	Red	Limestone	Granitic
P (in presence of S and Mo)	2170	868	1204	876
S (in presence of P and Mo)	104	115	15	19
Mo (in presence of P and S)	16	45	3	99

The effect of treatment on the limestone soil relative to that on the other soils is shown in Tables I and II. Of the types examined the limestone soil is considered by Christian and Stewart (1952) to have the greatest potential for agricultural development.

Acknowledgments

It is a pleasure to record the co-operation received from Messrs. C. S. Christian, G. A. Stewart and W. Arndt of the Land Research and Regional Survey Section, C.S.I.R.O., who were responsible for the collection and description of the soil samples.

Reference

Christian, C. S. and Stewart, G. A. (1952).—Survey of Katherine—Darwin Region, 1946, C.S.I.R.O., Land Research Series, No. 1.

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BOOK REVIEW

THE CULTIVATED RACES OF SORGHUM

By J. D. SNOWDEN

(*Available from Bentham-Moxon Trustees, Royal Botanic Gardens, Kew, Richmond, Surrey* 274 *pp.* 10/6 *plus postage*).

The importance of grain Sorghums, an extreme large group of tropical cereals, as a source of food for man and beast is now widely recognised by agriculturalists and others dealing with world food-shortages. Over large areas of Africa and tropical Asia, the grains of these plants form an important part of the diet of the natives, whilst elsewhere, especially America they are used extensively as food for domestic animals.

There are many thousands of local varieties, differing much in structure, yield and growth requirements. Their identification is difficult. It is not generally known, however, that a comprehensive survey of them was undertaken about twenty years ago, when as the result of an appeal issued in the British Commonwealth and in many other countries, several thousand flowering and fruiting heads, together with much valuable data concerning them, were received at Kew. The material was utilized in the preparation of this book by J. D. Snowden, at one time Economic Botanist in the Uganda Protectorate.

In its 274 pages, the book includes not only a classification and descriptive account of the 31 botanical races and of their numerous varieties and forms, but also detailed information on their distribution, culture and economics, together with an extensive bibliography of twelve pages, indices of botanical and vernacular names, and numerous illustrations. It is a work which should be in the libraries of all agricultural officers dealing with tropical field crops, and of everyone generally interested in economic botany.

DR. A. R. CALLAGHAN

PRESIDENT, 1953

The President of the Institute for 1953-54 is Dr. A. R. Callaghan, C.M.G., D. Phil., B.Sc. (Oxon.), B.Sc. Agric. (Syd.), Director of Agriculture in the Department of Agriculture, South Australia.

Born at Perthville, New South Wales, he spent his early life on his father's property at Bathurst, completing his secondary education with matriculation from Bathurst High School. He entered the Sydney University and graduated with the Bachelor degree in Agricultural Science in 1924, when he was selected as the New South Wales Rhodes Scholar for 1925. He continued his studies at Oxford, specialising in cereal work, and obtained the degrees of Bachelor of Science and Doctor of Philosophy.

Upon his return to Australia in 1928, Dr. Callaghan was appointed Assistant Plant Breeder in the New South Wales Department of Agriculture, stationed at Cowra, and from 1930 to 1932 he was in charge of the plant breeding work at the Wagga and Temora Experimental Farms.

In 1932 he came to South Australia as Principal of Roseworthy Agricultural College and achieved outstanding success in this position, showing great ability as an administrator. In addition, his activities in sponsoring a system of wider rotations and livestock farming in cereal growing areas soon made him well known to South Australian farmers.

During the last war, Dr. Callaghan was seconded to the Commonwealth Department of War Organization of Industry and as Assistant Director (Rural Industries) he was responsible for the oversight of the Department's activities of increasing food production and controlling distribution.

Early in the war years, it was recognized that provision would have to be made for land development in South Australia and the settlement of ex-servicemen. Accordingly, in 1940 the Crown Lands Development Committee was formed, with Dr. Callaghan as its Chairman. This Committee planned much of the subsequent developmental work which has been a prominent feature of South Australian agriculture since the war.

Dr. Callaghan's services to agriculture received official recognition in 1945, when he was awarded the C.M.G. in the Birthday Honours.

When the war was over, a start was made to implement the earlier-made plans for land development and settlement. Dr. Callaghan was appointed Chairman of the Land Development Executive in 1945 and this body set about the task of clearing and improving hundreds of thousands of acres of undeveloped and underdeveloped land in the higher rainfall areas of South Australia, bringing it up to the stage where ex-servicemen could take over productive farm areas.

In 1949, Dr. Callaghan was appointed Director of Agriculture and so became responsible for the leadership and direction of South Australia's extension services in agriculture. He continued in his position as Chairman of the Land Development Executive until 1951, but increasingly his efforts have been devoted to securing for South Australian farmers an advisory service second to none in Australia.

He became a foundation member of the Institute in 1935 and was one of the first delegates of the South Australian Branch to the Federal Council. In 1940 he was elected President of the South Australian Branch.

As Federal President this year, Dr. Callaghan brings to bear a marked executive faculty and a facility of expression which will serve the Institute well in its endeavours to further the causes of scientific agriculture and agricultural scientists.

HONORARY GENERAL SECRETARY

MR. H. P. C. TRUMBLE

At the 20th Annual General Meeting of the Institute, held on March 23rd last, when the headquarters of the Institute were transferred from Canberra to Adelaide, Mr. H. P. C. Trumble was appointed Honorary General Secretary.

Mr. Trumble, who graduated in Agricultural Science at the University of Adelaide in 1948, is Scientific Liaison Officer in the South Australian Department of Agriculture, acting in this capacity as a technical secretary to the Director of Agriculture.

COUNCIL PROCEEDINGS

The 132nd Meeting of Council was held in Adelaide on July 14, 1953.

Present

The President, Dr. A. R. Callaghan (Chairman), Dr. T. J. Marshall (Queensland), Dr. R. N. McCulloch (N.S.W.), Dr. H. G. Andrewartha (A.C.T.), Mr. G. M. E. Mayo (Victoria), Mr. D. S. Riceman (S.A.), Mr. N. R. McKeown (W.A.), Mr. T. T. Colquhoun (Hon. Gen. Treasurer), and Mr. H. P. C. Trumble (Hon. Gen. Secretary).

Apology

An apology was received from Mr. H. K. Kemp, and Tasmania was represented by the Hon. Gen. Secretary.

Arrears of Subscriptions

The Treasurer reported that a substantial amount of arrears had been collected since the previous Council meeting — a total of £132. Much work, however, is still necessary to collect the outstanding overdue subscriptions, amounting to more than £380.

Increased Membership

At the previous meeting the Treasurer had indicated that the increased membership was likely to exceed the registered maximum of 1,000. In order to cater for this increase, the Secretary was instructed to arrange for the Institute's solicitors to register under the Companies Act in Victoria an increased membership maximum of 2,000.

Appointment of Auditors

The Secretary presented three offers from firms of accountants to undertake the auditing of the Institute's accounts. After discussion, Council decided to accept the offer of Messrs. Milne and Burgess, and they have been appointed to this position.

Council-in-Person Meeting

In discussing the financial statement presented by the Treasurer, it became apparent to Council that the expense of a Council-in-Person meeting, as proposed for August, would probably be unwarranted, since there was not a great deal of important business for discussion by Principal Delegates. The state of the Institute's finances, in the light of anticipated expenditure over the next few months, made it quite clear that this meeting should be postponed if possible. The position is to be reviewed at the next Proxy-Council meeting, and it will then be decided if a personal meeting of delegates before the January meeting in Canberra is necessary.

Emeritus Membership

When this class of membership was established no decision was made with regard to the rate of rebate to which a Branch should be entitled in respect of its Emeritus Members. The Treasurer suggested that either no rebate should be payable, or a rebate equal to half that paid on account of a Corporate Member, since the subscription for Emeritus Members is half the Corporate subscription.

Honorary Life Membership

Council unanimously elected Professor W. L. Waterhouse and Professor R. D. Watt to Honorary Life Membership. Nominations have been received from the New South Wales Branch.

Membership

Admissions

With the recommendation of the Branch submitting the application and of the Qualification Committee, the following applications were approved for **Corporate Membership.** Unless otherwise indicated, admission was made under Clause 4 (i).

Bouma, D., South Australia.
Cuthbertson, K. J. McK., South Australia.
Dewey, D. W., 4 (iii), South Australia.
Groenewegen, H., South Australia.
Jefferies, B. C., South Australia.
Jones, G. B., 4 (ii), South Australia.
Kuchel, R. E., 4 (ii), South Australia.
Kuiper, J., South Australia.
Lee, H. J., 4 (ii), South Australia.
Lines, G. E., South Australia.
Pierce, A. W., 4 (ii), South Australia.
Quinlan-Watson, T. A. F., 4 (ii), South Australia.
Roark, B. A., 4 (ii), South Australia.
Specht, R. L., 4 (ii), South Australia.
Smith, R. M., 4 (ii), South Australia.
Weller, R. A., 4 (ii), South Australia.
Henzell, E. F., Queensland.
Lee, G. R., Queensland.
Talbot, R. J., Queensland.
Brown, R. H., Victoria.
Dettman, Miss M. G., Victoria.
Holmes, D. J., Victoria.
Hyland, P. G., Victoria.
Lahovary, N., Victoria.
Lewis, K. G., Victoria.
Osborne, W. B., Victoria.
Peggie, I. D., Victoria.
Webb, K. M., Victoria.
Adamson, D. A., New South Wales.
Barr, D. A., New South Wales.
Davey, B. G., New South Wales.
Donavon, Miss K. O., New South Wales.
Lynch, B. T., New South Wales.

Student Membership

With the recommendation of the Branches submitting the applications, the following applicants were admitted to **Student Membership:**—
Colman, R. L., New South Wales.
Corbin, J. B., New South Wales.
Gibson, A. H., New South Wales.
Gregory, Miss A., New South Wales.
Hassall, H. M., New South Wales.
Houlahan, P. M., New South Wales.
Jane, Miss A. E., New South Wales.
Killeen, I. D., New South Wales.
Musgrave, W. F., New South Wales.
Quigan, Miss J. M., New South Wales.
Shand, R. T., New South Wales.
Thompson, I., New South Wales.
Vickery, R. S., New South Wales.
Vitols, E., New South Wales.
Weeks, Miss J. A., New South Wales.
White, J. O., New South Wales.
Donaldson, T. W., Victoria.
Elliott, N. M., Victoria.
Lenaghan, J. J., Victoria.
Wardrop, I. D., Victoria.
Basu, M. C., Queensland.
Cowan, A. J., Queensland.
Rule, L. M., Queensland.

Transfers

The following transfers were noted:—
Costin, A. B., New South Wales to Victoria.
Jarrett, F. G., New South Wales to South Australia.
Norris, K. R., Australian Capital Territory to Queensland.

BRANCH NOTES

Australian Capital Territory.

Mr. K. P. McGrath, Senior Lecturer of the Australian Forestry School, Canberra, addressed a meeting of the Branch on 28th May, 1953, on the subject "Possibilities for Development in Agriculture and Forestry in the Amazon Basin". Mr. McGrath visited the Amazon as a member of a F.A.O. mission to report on the possibilities for development in the area. The speaker spoke of the practical difficulties in the way of large scale settlement, namely the climate, the vastness of the area and the failure to develop agriculture to any significant degree.

Rain forest covers 95 per cent. of the total area of the Amazon Basin of which Brazilian Amazonia comprises 2 million square miles.

The forests are low yielding and poor in quality but because of the size of the area, the flat terrain and excellent transport facilities by medium of the 20,000 miles of navigable waterways there is promise of a stable, economical timber industry. The most important timbers are mahogany, of which there is a very large belt, and cedar, which is present over the whole area. The possibility of agricultural development is bound up with the forestry industry but attempts to build up agricultural communities in the past have failed. The soils in general are laterized and low in fertility, and unless re-

search can reveal methods of overcoming their limitations and deficiencies, it is thought that the possibilities for agricultural development are not favourable.

Mr. J. G. Crawford, Mr. F. H. Strong and Mr. R. R. Pennefather were the speakers at the meeting held on the 2nd July, at which the subject was "Present Problems of Extension in Australia". The meeting followed closely upon a Conference on Extension held in Adelaide from June 22-26 and each speaker made reference to this.

Mr. Crawford, in introducing the subject, raised certain questions at the Conference dealing with the methods available for getting the scientific and technical knowledge over to the farmers, whether the extension workers were getting to know of scientific advances, whether the States were satisfied with their present extension methods and whether research is well enough directed towards meeting the needs of the farming community.

He stressed the need for the extension worker to understand the broad economic factors of the crops with which he is working and also the desirability for the careful planning of extension work. The shortage of extension workers was critical and a large proportion of the Commonwealth grant for extension may have to be directed towards making available the supply of personnel.

Mr. Strong discussed some of the problems raised at the Conference, particularly the problems of extension and research, training facilities for extension personnel and the need for meeting an enlargement of the extension services. It was realized that the plan of trained personnel was hopelessly inadequate and the existing university schedules present a gloomy outlook. A fifth year specialization in psychology, elementary political science and commonwealth state relationships is a necessity in the training of extension workers. The alternative would be a special course five years after graduation and following field experience.

A freer flow of personnel from research to extension has been suggested as one means of meeting the shortage but sufficient numbers of adequately financed scholarships for specialised training are imperative.

Mr. Pennefather said that technical aspects of the problems that confronted agriculture could be the subject of far greater discussion and considered the Australian Institute of Agricultural Science could play an important role in this regard. The Commonwealth must work out ways of bridging the gap between the State Departments and C.S.I.R.O. by further conferences and discussions of the type of the Southern Tablelands of New South Wales tour in 1952.

New South Wales

A joint meeting was held with the Australian Society of Animal Production, New South Wales Branch on 29th June. The main business was an address by Professor F. W. Day, Associate Professor of Animal Genetics at the Massey Agricultural College, New Zealand, entitled "Mendelian Inheritance in the New Zealand Livestock."

Professor Day's particular interest has been the genetics of the Romney Marsh sheep, especially the inheritance of hairy wool. His comments on the phenotypic expression of heterozygosity in this, and other animals, were most interesting. In the Romney sheep the recognition of heterozygotes for hairiness have been worked out well. Some have only a few coarse hairs, the effects of the gene for hairiness being considerably damped down by the effects of other factors. The effects of modifying factors on the appearance of red hair colour in Lincoln pigs was discussed. Although white is the dominant hair colour, in the heterozygous condition the gene for red has some effect which is influenced by other modifying factors.

The speaker went on to comment on the recognition of identical twin calves, which although they have the same genetic composition, cannot be expected to produce phenotypes which are exactly the same. Professor Day concluded with a reference to lethal and sub-lethal factors in livestock which, though not uncommon, are of no great practical importance.

Queensland

The May meeting was devoted to notes and exhibits. Mr. W. J. S. Sloan spoke about tea-growing at the Bureau of Tropical Agriculture at South Johnstone in North Queensland. An area of about half an acre which was planted in 1942 is now being used to determine (a) whether tea of satisfactory quality for Australian consumption can be produced, and (b) the cost of harvesting under Australian conditions of labour.

Samples of tea obtained at monthly intervals over a period of two years have been submitted to test. Pluckings made in the warm moist months of the year provide a satisfactory yield of good quality, but during the cool dry months yields are poor or negligible and quality is low.

In 1951 a small mechanical tea harvester, operated while held in the hand, was available, and a comparison of costs for hand plucking and mechanical harvesting was made. The cost per pound of commercial tea was 5/8 for mechanical harvesting and 12/2 for hand plucking. While this cost is too high, the trial did reveal that mechanical harvesting is possible, and that the quality of the tea is not impaired by this method of picking. It will be some years before the effect of mechanical harvesting on the tea plant can be assessed.

Attention is now being directed to the possibility of providing permanent ways in tea gardens so that large scale tea harvesters might be moved along rows of tea plants. It is hoped that a machine harvester will be available for trial by 1955.

Work now being undertaken by the Bureau includes an investigation of legumes for ground cover and for shade, and trial plantings of tea at Kairi and East Palmerston, areas of higher elevation than South Johnstone.

Mr. Sloan also outlined the work being carried out at the Wrotham Park Exploratory Farm, which is 50 miles north-west of Chillagoe.

Mr. J. E. Coaldrake exhibited a card sorting system for the field identification of Eucalypts, and Mr. S. Marriott spoke about the conservation of pasture grasses as hay. A film depicting the methods used on Colwell Station in north-western Queensland was shown.

At the meeting in June, members were addressed by Mr. J. F. Miles, a Senior Plant Introduction Officer of the C.S.I.R.O. who recently spent fifteen months in Africa and the Mediterranean Region. While showing an extensive series of colour transparencies Mr. Miles commented on many phases of agricultural practice and research in Africa. The speaker concluded that in Africa there were many plants available for exploitation by Australia. A comprehensive study of the reconnaissance collection of material that he brought back will determine its indicator value and disclose the most profitable trends to pursue in subsequent plant introduction.

South Australia

The South Australian Branch decided to invest some idle funds when the C.S.I.R.O. Advisory Council came to Adelaide in June, and the visiting Council members were entertained at a buffet tea in the University Staff Clubrooms.

The evening was voted a great success by all concerned.

Victoria

Mr. Hedley Marston, F.R.S., addressed a general meeting of the Branch on 24th July on the subject "Cobalt Deficiency in Ruminants and its Implications". He described the discovery and identification of cobalt deficiency in sheep and discussed recent work on the nutritional function of cobalt, its association with microbiological activity in the rumen, its relationship to vitamin B12, and possible implications with respect to the mechanism of the nutritional role of antibiotics.

Mr. Marston, also described the action of cobalt in protecting sheep against Phalaris staggers and pointed out that recent experiments had shown this action to be dependent on the administration of cobalt by mouth; vitamin B12 administered parenterally was ineffective. Other points of particular interest included the effect of cobalt on appetite in pen-fed sheep and studies of species differences between plants in uptake of heavy metals.

Before the meeting, members attended a buffet tea at C.S.I.R.O. canteen.

Western Australia

A combined meeting of the Clinical Staff of the Royal Perth Hospital and the Western Australian Divisions of the Australian Institute of Agricultural Science and the Australian Veterinary Association was held on the 19th June to hear a symposium entitled "Trace Elements with Particular Reference to Copper."

The three speakers, Mr. A. B. Beck, Dr. T. C. Dunne and Dr. J. Stokes, gave an account of the part played by the trace element copper, in the animal, the plant, and in man.

With respect to animals it was of local interest to learn that in Western Australia our research workers were the first to demonstrate copper deficiency in farm animals. Copper is an element of economic importance to the State in both plant and animal production.

Large areas of Western Australia, especially the lighter soils, have been shown to be copper deficient for plant growth. The control of copper deficiency in agricultural and horticultural crops is complicated by the different requirements for copper of the various plants.

In man, as in animals, the main recognised function of copper is the part that it plays in the formation of the haemoglobin of the blood. In very rare cases copper may be stored in certain body tissues in abnormal and even toxic amounts. The exact reasons for this have not yet been defined.

This year the Branch Committee has formed a number of Sub-Committees to facilitate initially the handling of Institute activities. It is hoped later to enlarge the number and scope of such Sub-Committees so that more members can take an active part in Branch affairs and thereby further the aims of the Institute. The following Sub-Committees have already been formed and their titles and respective convenors are as follow:

Advertising and Publicity . . Mr. L. T. Jones.
By-Laws . . . . . Mr. M. M. H. Wallace.
Programme . . . . . Mr. S. T. Smith.
Social . . . . . Mr. B. J. Quinlivan.

A general meeting held on the 20th July heard an address by Mr. F. Penman, Officer-in-Charge of the Merbein Research Station, entitled "Nitrogen in Soil and Plant". Mr. Penman described studies at Werribee, Rutherglen, and other localities, which demonstrated the failure of short rotation practices to maintain soil nitrogen and organic matter levels. Subterranean clover pastures proved effective in reversing the downward trends in soil fertility and wheat yields, but chemical analyses showed no appreciable increase in soil nitrogen for the first two years of the clover ley.

At Merbein, green manuring practices with legumes have been successful in maintaining soil nitrogen and organic matter levels under sultana vines, but no response in yields has been obtained.

PERSONAL NOTES

Australian Capital Territory

Dr. O. H. Frankel, F R.S., Chief of the Division of Plant Industry, CSIRO, left during August on a brief visit overseas. He first visited F.A.O. Headquarters in Rome and then attended the 9th International Genetics Congress at Bellagio, Northern Italy, where he was invited to deliver a paper, selecting for his subject "Invasion and Evolution of Plants in Australia and New Zealand". Subsequently, Dr. Frankel will visit England and possibly some of the Scandinavian countries in connection with

proposals to advance development of research in genetics and biochemistry in the Division of Plant Industry.

Dr. Frankel will return to Australia via the U.S.A. and will be absent from Australia for about six weeks.

Mr. R. Milton Moore has been elected Vice-President of the Branch in succession to Mr. F. O. Grogan who resigned prior to going abroad for a term of 1½ to 2 years. Dr. D. B. Williams of the Bureau of Agricultural Economics has taken the place on the Committee formerly occupied by Mr. Moore.

Mr. L. F. Myers, M.Agr.Sc., Division of Plant Industry, CSIRO. Canberra, sailed for England in August. Mr. Myers will undertake post graduate work under Prof. G. E. Blackman at the University of Oxford. His main interest will be experimental ecology with special reference to weeds.

Mr. F. O. Grogan, of the Bureau of Agriculture Economics, has left Canberra for exchange duty in London with the United Kingdom Ministry of Agriculture and Fisheries. Mr. Grogan expects to remain in London for about eighteen months.

Dr. D. O. Norris of the Division of Plant Industry, CSIRO, Canberra, will be transferring, shortly before Christmas, to Brisbane. Dr. Norris has been with the Division of Plant Industry in Canberra since 1938, where he has worked principally with plant virus diseases. In Brisbane he will join the regional Plant and Soils Laboratory of the Division, under Dr. J. G. Davies, and will be concerned with Rhizobium problems of tropical and sub-tropical legumes, working in close association with the plant introduction and agrostology research groups.

New South Wales

Mr. J. Goivanelli, a recent graduate, is proceeding to the University of California at Berkeley where he will be working in the field of plant biochemistry. He was awarded a scholarship from that University as well as a CSIRO studentship.

Mr. A. D. Rovira, teaching fellow in Agricultural Microbiology at the University of Sydney, is proceeding on a CSIRO studentship. He will study soil microbiology at the Institute of Microbiology, Uppsala, Sweden.

Miss D. E. Shaw, Plant Pathologist at the University of Sydney, has been awarded a Walter and Eliza Hall Travelling Scholarship. She will continue her study of leaf diseases of cereals at the Dominion Laboratory of Plant Pathology, Winnipeg, Canada.

Mr. W. F. Owen has resigned from the position of Economics Research Officer in the New South Wales Department of Agriculture. He is leaving for further study at Oxford after which he will join the staff of the University of Wisconsin.

Dr. F. C. Butler, Plant Pathologist with the New South Wales Department of Agriculture, has been appointed Plant Pathologist at the new Wheat Research Institute at Wagga. Dr. Butler has specialized on the root rots of cereals and it is understood that he will also be investigating the ecology of soil fungi in relation to cereal problems.

Mr. G. R. Meadly attended the New Zealand Weed Conference which was held at Palmerston North from the 18th to the 20th of August.

Mr. T. C. Miller has returned to the Western Australian Department of Agriculture after 3 years in Pakistan where he was Director-General of Agriculture, northwest Province.

Queensland

Mr. V. J. Wagner has been appointed Senior Agronomist, Department of Agriculture and Stock, Queensland.

Dr. H. E. Young, Director of the Rubber Research Institute, Agalawatta, Ceylon and *Mr. A. J. Schindler*, Manager of the Agricultural Experiment Station, Aiyura, New Guinea are in Brisbane on leave.

Professor L. J. H. Teakle, Professor of Agriculture, University of Queensland will be on study leave during 1954. He will spend about eight months in the United States of America, and then visit Great Britain, Holland, India and Ceylon before returning to Australia.

South Australia

Mr. T. T. Colquhoun, Hon. Federal Treasurer (AIAS) and until recently Deputy Director of War Service Land Settlement in South Australia, has been appointed Acting Director of WSLS and is at present living in Canberra.

Mr. J. K. Powrie, Assistant Plant Nutrition Officer, Division of Biochemistry and General Nutrition, CSIRO, who returned recently after a year in Europe has been appointed as Agricultural Liaison Officer with the Department of Agriculture and will be stationed at Keith in the Upper South-East of South Australia.

Dr. C. G. Stephens, head of the Soil Survey and Pedology Section, Division of Soils, CSIRO, returned recently from Norfolk Island where he helped to carry out a Soil Survey made at the request of His Honour the Administrator (Brig. Norman).

Victoria

Mr. E. G. Pont, Chemist and Bacteriologist in the Dairy Research Section, CSIRO, left Australia in May to attend the 13th World Dairy Congress in Holland. He is also enquiring into research on oxidative defects in dairy products, and will return to Australia via the U.S.A.

Mr. I. D. Marshall has been awarded a scholarship by the National University for work in the John Curtin School of Medical Research. He will continue his work on myxomatosis under Professor Fenner, on which he has been engaged at the Hall Institute for Medical Research.

Dr. C. R. Millikan, Senior Plant Pathologist, Burnley, has received a Fulbright Smith-Mundt Award of the U.S. Government which will enable him to spend 8 months at the California Institute of Technology, Pasadena, He will work in plant nutrition with special reference to the effects of climatic factors upon the severity of zinc deficiency.

Mr. J. L. Gillespie, formerly of the Victorian Branch but recently engaged in farming in New South Wales, has now joined the Agricultural Research Liaison Section of CSIRO. He will be engaged primarily in the preparation of reports and publicity based on research results for use by extension officers.

Western Australia

Professor E. J. Underwood has left for Bangalore, India, to represent Australia at a conference of the Asiatic section of the FAO. He will also visit research institutes in India and Ceylon.

Mr. K. W. Finlay has been awarded a Ph.D. by the University of Western Australia, for work on the genetics of spotted wilt resistance in tomatoes. He was appointed recently as Plant Breeder in the West Australian Department of Agriculture.

Mr. A. W. Humphries has been appointed to the Agrostology Section of the Division of Plant Industry of CSIRO. He will study the ecology of pasture species.

Mr. L. C. Holmes has taken up the position of Trade Commissioner in Cairo.

LETTERS TO THE EDITOR

Sir,

To an Australian audience the article by Dr. K. O. Campbell in the June issue of this Journal, on "The Conditions of Increased Productivity in Agriculture," is novel, timely and important. It is for these reasons that I would like to join issue with Dr. Campbell.

Firstly, on his application of the widely-known general theory of the "distribution of the benefits of technical progress." This general theory has been put succinctly by Dr. Campbell as follows: ". . . the demand for most agricultural products is inelastic. This means that the increase in output which, in most cases flows from a new technology in a particular industry, causes the price of the product to fall to such an extent that a lower total revenue is received from the sale of the product . . . than when output was less." Thus there is a "tendency towards lower incomes." With this theory most economists are in agreement. It must be remembered, however, that it is a theory, only a first approximation to reality, rather than Dr. Campbell's "typical pattern."

It seems that Dr. Campbell only grudgingly allows "other situations where prospects are brighter . . .", and that "on occasions farmers, by collective action, can . . . retain(ed) . . . the income derivable from increased productive efficiency," and "it is possible . . . (to) . . . offset somewhat the income-reducing properties of new farm technologies." In fact, these seem to have been the rule rather than the exception in the immediate past, and they appear to be likely to continue. For instance, where the prices of agricultural products are fixed according to cost of production formulae, as they are in so many cases, wheat, eggs, sugar, potatoes, whole milk, and butter and cheese until recently, to name a few, an implicit assumption upon which the theory relies no longer holds, viz., that changes in the volume of production are automatically reflected in changes in the price. Another implicit assumption is that the number of farmers is either constant or it does not fall at a rate sufficiently rapid to offset the effect of a price fall. Whether this has happened in the immediate past or is likely to happen in the immediate future is also very doubtful.

Anyhow, even if these two assumptions do hold, and granting the **ceteris paribus** condition, it is a pity that Dr. Campbell should choose to focus attention upon the "income-reducing properties of new farm technologies," rather than the two-fold condition of a progressive economy in which **real incomes rise through the rapid acceptance of technical innovation and the consequent rapid reallocation of labour and capital.** This would seem to be the more helpful approach, especially now, in Australia, where Departments of Agriculture are groping towards a major improvement of their extension services.

The second point is in reference to "the provision of information." Dr. Campbell has done well to point out that "the exact function of the extension worker is too narrowly defined." Further, I am in complete agreement with the farm management approach he advocates, and the value of which, if realised at all by Australian Universities and Departments of Agriculture, has not yet commended itself to the point at which they are prepared to take action. However, the case for a different approach to extension does not rest on the results of a survey such as the Iowa study. Nor does Dr. Campbell's conclusion that such surveys ". . . point towards the role of extension in getting farmers to adopt new practices as being a relatively minor one . . .", follow from the facts cited.

Spectacular as the results of the Iowa study are, it is likely that they will be eclipsed by the results of a survey in progress in Western Australia. Here it is expected that few, if any, farmers will credit the Department of Agriculture as being of any influence at all in their adoption of new varieties of wheat. It is probable that the Department will score even less, if at all, on the change involved in fallowing with a scarifier instead of a plough, or tailing with rubber rings instead of a knife. On the other hand, salesmen would not score at all in their influence on the adoption of contouring or the substitution of machine stripping for the hand stripping of cows. In these fields the Department of

Agriculture would score full marks. Dr. Campbell's conclusion should read ". . . point towards the role of the extension service in getting farmers to adopt hybrid maize as being a relatively small one."

One final point. In the section dealing with "the role of government . . ." Dr. Campbell concludes that "special attention needs to be given . . . (inter alia) . . . to the complex of influences which affect farmers' expectations as to the future." Without disputing the importance in economic theory of the role of entrepreneurial expectation, I very much doubt that "farmers' expectations as to the future" exist, except perhaps for an uninfluential few. My own observations lead me to the tentative conclusion that farmers do not act according to a concept of the future. They simply do not know what the future holds (economically), and they appear to act according to their experiences of the past and within their capacities of the present and perhaps the next season. Thus, the repayment of debt and its avoidance, in the face of profitable investment opportunities, seem to be a compelling pattern of behaviour, in spite of such inducements to invest further, as provided by especially high depreciation allowances. Dr. Campbell presumes that farmers have got expectations, and considers that they should be influenced. On the other hand, I doubt whether they have any that are important, and I think they should be helped to formulate them. This difference is real and important.

In conclusion, my differences with Dr. Campbell are mainly in emphasis. I think it is important, however, that the emphasis in the analysis he has made not be misplaced, especially now that State and Federal Governments appear to be taking some few faltering steps towards improvements in agricultural production and productivity.

Yours, etc.

HENRY P. SCHAPPER.

University of Western Australia,
18/viii/1953.

Sir,

Those responsible for editing the Journal of the A.I.A.S. should be congratulated on the development of the Journal over recent years. The review articles and those dealing with broad and fundamental issues of Australia's primary industries are of the greatest interest, especially to the specialist who is in danger of losing touch with the development of agriculture as a rather complex and integrated industry. In my opinion, the present editorial policy should not only be continued but further developed so that the A.I.A.S. might play a more conspicuous part in influencing Australia's development.

The article by K. O. Campbell in the June issue of the Journal showed the relatively slow progress Australia's primary industries have made since 1939. Measures were described which Governments can take to stimulate these industries and to increase their output and efficiency. The application of such measures could improve the service these industries can render to the Australian community, to the consumers of the world, and, last but not least, to the producers themselves.

Prices of agricultural products, particularly the relationship of such prices to each other, taxation and credit policy, are the most powerful influences in determining primary production within the limitations set by climate, soils, location of markets and the human element.

The A.I.A.S. through its members should take a more active part in the framing of a comprehensive Agrarian Policy by discussions and publications, and by stressing the importance of providing better training and research facilities for the sciences of agricultural economics and farm management at the Agricultural Schools of the Universities.

The limitations of cost-surveys for agricultural and pastoral products are still inadequately appreciated except by a small group of professional agricultural economists. Often, in estimating production costs, a single crop or animal product is considered isolated from the farm as an organic harmonious unit, in which each branch of production is related to another with the object of making the whole farm an economic enterprise without depleting the fertility of its soils. Furthermore, fixation of prices for agricultural commodities, if based on "average price" cost surveys of the random sample type, tend to be biased towards an overestimation of costs. Such a price level, especially if combined with the present system of income taxation, might not be stimulating to an increase of productivity and efficiency, nor might it be in the long-term interest of the producer.

Agricultural research of a biological nature has made great contributions over the last 50 years, with the effect that the gap between available technical knowledge and average production technique on the farm has become wider and wider. An improved extension service is one way to narrow this gulf. However, this extension service has to be supported by an Agrarian Policy which is comprehensive and based on surveys and studies of independent agricultural economists and students of farm organization. Some valuable work, such as the Beef Cattle Survey, has already been made in this direction.

I hope, Sir, that these lines might stimulate more discussion and thought on these problems by members of the A.I.A.S., and thus further the "interests of Agriculture in the Commonwealth", as set out in section 2, (ii) of the A.I.A S.'s Memorandum of Association.

Yours, etc.

F. SKALLER,

Werribee, Vic.
1/viii/ 1953.

NEWS ITEMS

Funds for Soil Research in Western Australia

On 29th July at the Annual Conference of the Farmers' Union of W.A. the Wheat Section passed, almost unanimously, a resolution in favour of a compulsory levy of ¼d. per bushel on all wheat marketed in Western Australia to provide funds for research by the Institute of Agriculture of the University of Western Australia aimed at raising the fertility of wheat-belt soils. A levy of this amount would provide about £30,000 per annum at present levels of production. It is to constitute a trust fund to be administered by three representatives of the wheatgrowers with the Director of the Institute.

To implement this scheme an amendment to the State wheat marketing legislation is necessary.

Even so, the resolution gives great encouragement to the Director of the Institute (Professor E. J. Underwood) and his staff and is a striking tribute to him and the research he has been able to initiate with very limited resources as well as being evidence of the progressive outlook of Western Australian wheatgrowers.

Public Meetings of Extension Workers on Beef Cattle Production

Under the auspices of the Australian Committee on Animal Production, a conference of extension workers on beef cattle was held in Victoria from 24th to 28th August. The Australian Meat Board each State Department of Agriculture, CSIRO, the Northern Territory Administration and beef cattle producers from the Southern States were represented. The conference was itinerant and met at Benalla, Hamilton and Camperdown. Public meetings were held in these centres and were attended by district farmers and graziers. At each meeting local producers opened discussion with descriptions of district practices. Comments in the light of recent experimental work in Australia and abroad were given by Dr. R. B. Kelley, CSIRO, on breeding, by Dr. M. C. Franklin, CSIRO, on feeding and by Mr. D. B. Muirhead, Department of Agriculture, South Australia, on management.

Agricultural Research Station Established by Imperial Chemical Industries

I.C.I. has announced that it will set up a biological research centre on a property of 140 acres at Croydon, Victoria. It will be one of the largest and most modern commercial laboratories of its type with excellent facilities for research on agricultural chemicals and their use as insecticides, fungicides, weed-killers and therapeutic preparations. A large testing programme for chemicals will be centred at the laboratory and extended in field trials throughout Australia.

Director of the laboratory and leader of the research team will be Mr. F. J. D. Thomas, entomologist, who was formerly director of the company's Hawthornedale laboratories in England and who was discover of the insecticidal properties of benzene hexachloride. He is due to arrive here in September.

New Entomological Society

As a result of the activities of a keen Sydney group, the Society of Entomologists—Sydney was formed earlier in the year. At the inaugural meeting held in February, there was an attendance of almost 100 interested persons and the present membership is 125. Office bearers are—

President: C. E. Chadwick, New South Wales Departmental of Agriculture.

Secretary: E. L. Jones, New South Wales Department of Agriculture.

Treasurer: P. Hadlington, Forestry Commission of New South Wales.

The aims of the society are, broadly, encouragement of interest in entomology and the wide membership includes professional entomologists, pest control operators, insecticide manufacturers and amateurs. Meetings are well attended and addresses on a variety of subjects have stimulated interesting discussions. This experiment in bringing together professional and practical people already seems sure of well worthwhile results.

Regional Surveys in Queensland and Papua

The Land Research and Regional Survey Section of CSIRO has two units in the field this year, one in the Gulf Country of Queensland and one in Papua. Mr. C. S. Christian, the Officer-in-Charge of this Section, left Canberra to join the mainland unit on 14th July. This unit is being led by Mr. R. A. Perry, plant ecologist to the section. On 3rd August, Mr. Christian proceeded to Papua and spent several weeks with the unit which is now operating under the leadership of the Section's Senior Survey Officer, Mr. G. A. Stewart.

Dr. K. O. Muller

Dr. K. O. Muller arrived in Canberra on July 22 to join the Microbiology Section of the Division of Plant Industry of CSIRO. Dr. Muller was born in Berlin in 1897, and for nearly 15 years was with the Department of Applied Genetics at the Biologisch Reichsanstalt and Professor of Phytopathology at the University of Berlin. During this period he also spent two years in Ankara to establish the Institute of Botany and Phytopathology for the Turkish Government. After the war, in 1948, he transferred to Cambridge where he worked at the National Institute of Agriculture and Botany. From August 1951 to April 1952 he was in South America as F.A.O. adviser to the Government of Chile in connexion with a devastating outbreak of potato blight previously unknown in that country.

Dr. Muller's main interest for many years has been on the fundamental host-pathogen re-

lationship in Plant Pathology. In Germany he undertook research on the immunity of the potato to Blight, discovered the first genes for suprasensitivity of the potato to Blight and investigated the mode of inheritance of this factor. His breeding material was widely spread and was serving as the basis for Blight resistance in many breeding programmes. Much attention was also given to breeding for virus resistance in the potato, and to a variety of plant disease problems.

In Canberra Dr. Muller will continue his work on suprasensitivity and other mechanisms of resistance in plants, and the action of the genes involved in the cell metabolism. An attempt will be made to use pathogens of major importance to Australian Agriculture in these studies.

Dr. P. S. Nutman

Dr. P. S. Nutman has been appointed as a Senior Research Fellow at the Division of Plant Industry, CSIRO, for a period of three years. Dr. Nutman is a member of the Microbiology Department, Rothamsted Experimental Station, Harpenden, Herts., England.

Dr. Nutman's field of work was symbiosis in red clover. He has been particularly concerned with the mechanism of infection and with the genetic interrelation of host and bacteria affecting the efficiency with which nitrogen is fixed in the nodule.

Dr. Nutman hopes to carry out similar work on Australian clovers. He will work at the headquarters of the Division in Canberra.

CSIRO Dairy Research Laboratory

A tender has been accepted for erection of a new building at Highett, Victoria, to accommodate the Dairy Research Section of CSIRO. The estimated cost of the laboratory is £82,698. The Section, which is under the direction of Mr. G. Loftus Hills, is concerned with the technology of dairy products. Hitherto it has been accommodated with the Division of Industrial Chemistry at Fishermen's Bend.

Dairy Research Farm in Gippsland

The Victorian Department of Agriculture has acquired a property at Ellenbank, near Warragul, in Gippsland to be developed as a centre for research on dairy cattle. It is being subdivided into four independent farms each of which will be operated as a separate unit for investigation of a particular aspect of dairy production. Development is proceeding and it is hoped that the units will be established in 1954. The farms will be stocked in part with identical twin cattle for use in experimental work.

Fulbright Visitors

Dr. Raimon Beard, Dr. Barbara Stay and Mr. Eugene Irwin are visiting Australia from the U.S.A. under Fulbright Awards. Dr. Beard, from the Connecticut Agricultural Experiment Station, is working with the Division of Economic Entomology in Canberra on bacterial diseases of cockchafer beetles. Dr. Stay, from Harvard University, is engaged in histochemical studies in the same laboratories. She has studied cellular differentiation and metamorphosis in larva and pupa of the blowfly and here will pay special attention to enzymes in wool digesting insects and to the histochemistry of chitin formation. Mr. Irwin is studying trace elements and their role in animal nutrition at the Nutrition Laboratory, Adelaide.

Gift for Beef Cattle Research

Mr. William McIlrath, member of a prominent N.S.W. family with pastoral interests and owner of the Windsor Hereford Stud, Delungra, has made a gift of £50,000 to be used for the establishment of a Senior Research Fellowship in animal husbandry in the beef cattle industry. The fund will be administered by CSIRO.

Conference on Processing Pig Meats

At the instigation of the Australian Committee on Animal Production, a conference on production of bacon and ham was convened in Melbourne on 29th July. An attendance of about 60 persons from all over Australia included representatives of the Australian Meat Board, State Departments of Agriculture, CSIRO, Department of Commerce and Agriculture, Melbourne University, N.S.W. University of Technology, Wm. Angliss Food Trades School, Sydney Technical College and a number of firms engaged in curing bacon and ham. Dr. Vickery outlined the results of research which could be applied more widely in processing, and Mr. Downey discussed problems in the production of carcases suitable for the trade. The conference gained useful guidance towards improvements in curing techniques and took steps to organise more effective research, extension and education in the industry.

F.A.O. Fellow in Australia

Spending six months in Australia as the holder of a F.A.O. Fellowship is Mr. Amos Dovrat, Officer-in-Charge of Pasture Investigations at the Government Agricultural Experiment Station, Neveh Yaar, Israel. Mr. Dovrat underwent his training over a diverse field, viz. in Holland, Switzerland and Aberystwyth.

The Plant Introduction Section, Division of Plant Industry, CSIRO, has arranged Mr. Dovrat's itinerary in Australia. Visits to research laboratories and field stations in Western Australia, South Australia, Victoria, New South Wales and Queensland have been arranged in conjunction with the various State Departments of Agriculture and CSIRO Regional Research Stations. In particular, the irrigation areas of Victoria and the Falkiner Research Station, CSIRO, Deniliquin, will be visited during the course of his studies on irrigated pastures.

BOOK REVIEWS

GRASSLANDS OF NEW ZEALAND

By E. BRUCE LEVY

(Government Printer, Wellington, N.Z., 1951, 344 pp., 26/6).

"With its well-distributed rainfall and temperate climate, New Zealand is wonderfully endowed to produce food . . . derived mainly from *in situ* grazed grasslands with a minimum use of home grown fodders." Thus Bruce Levy assesses the grassland prospects of a country already at the forefront of the pasture regions of the world. Indeed he emphasises that the further development of New Zealand's pastures is of paramount importance to the entire economy of the country. Much remains to be done. Levy estimates that 90 per cent. of the 18 million acres of sown pasture fall short of full development and in addition great areas of potentially good pasture land remain unexploited.

E. Bruce Levy, who until his retirement last year was Director of the Grasslands Division of D.S.I.R., is well known for his many contributions to the grassland reputation of his country. He opens his book with an account of the ecological regions of New Zealand and of the influence of climate on pasture development. He continues with a discussion of other environmental factors, the breeding of pasture plants, problems of establishment, seed mixtures, intensive grassland farming, hill development and some economic aspects of rural development.

Throughout his book Bruce Levy emphasises three basic factors in pasture production — the vital roles of legumes, the liberal application of fertiliser especially in the early years and the interdependence of the pasture and the grazing animal. He has italicised only one sentence in the book, that *"Without clover, development to high productivity is impossible."* On this all modern pasture workers will agree. We are tending in Australia to use heavier fertiliser dressings, but it is nevertheless startling to read of recommended commercial applications of 9 cwt. of superphosphate per acre in the first year followed by 3 cwt. in the following years. One wonders whether the need to sustain such annual dressings has been confirmed. In discussing the animal Levy refers to the well known Palmerston results on return of nutrients and admission of light by the grazing animal. He does not hesitate to assert that the animal is so critical to pasture management that there will be many times when the animal must be forced by starvation to clean up a paddock.

There is much more of interest in his book, especially on such topics as intensive grassland farming and special purpose pastures. It is somewhat surprising to the Australian pasture worker that there is not even a reference to the possible role of trace elements. Also the seed rates recommended for permanent pastures are extremely high. It is difficult to believe that the potential gain in first year production would compensate for the heavy outlay in seed or that the established pasture would be significantly superior.

The book lacks evenness of treatment. The chapters seem to have varying emphasis for students, farmers and grassland workers respectively, and in some cases the treatment tends to fall between the three stools. The lack of any map of New Zealand is an irritating omission.

"Grasslands of New Zealand" contributes very materially to the literature on this subject by bringing together a great deal of New Zealand's applied research and practical experience on pastures, supported by Bruce Levy's great personal experience. It should play a significant part in advancing grassland development in New Zealand, and in stimulating grass-consciousness in many other countries.

C. M. DONALD.

LATERITE AND LATERITIC SOILS

By J. A. PRESCOTT and R. L. PENDLETON

(Commonwealth Bureau of Soil Science Technical Communication No. 47, 1952, 51 pp. Obtainable from the C.A.B. Liaison Officer at 314 Albert Street, East Melbourne, C.2. Price 7/6)

This booklet deals in thorough and scholarly fashion with the use of the word 'laterite', with the geography of lateritic country, and with opinions on how laterite is formed. It is written for the pedologist and the geologist, and makes only slight reference to the agricultural use of lateritic country.

The word has been used by various writers to mean concretionary ironstone and profiles associated with it, on the one hand; and dominantly red soils, on the other. The authors confine its use to the former meaning, and show that this was also the original meaning. Red soils have no necessary connection with laterite, and this second use of the word has caused much confusion. Prescott and Pendleton, both authorities in their own spheres, writing in British and American publications respectively, have played their parts in removing this confusion.

PUBLICATIONS RECEIVED

East Malling Research Station, Kent. Annual Report for 1952. (1953, pp. 190, 12s. 6d. English).

A thorough and very attractively presented report. Part 1 reviews operations on the experimental farm, and Part 2 describes the progress of research work in each of the Departments, which include Pomology, Plant Physiology, Biochemistry, Plant Pathology, Entomology and Plant Protective Chemistry. Part 3 consists of 27 individual research reports and reviews; subjects include American developments in fruit culture, new rootstocks, spring frost damage, designing of experiments, assay of growth substances, culture methods of growing trees. Eight bulletins for fruit growers appear in Part 4.

Hevea. Thirty Years of Research in the Far East. By M. J. Dijkman (University of Miami Press, Florida, and Chronica Botanica Co., Waltham, Mass., 1951, pp. xxii + 329).

The rubber tree, Hevea, originating in tropical America, has been the subject of intensive research during some 30 years, mainly in the Dutch East Indies and British Malaya. With the impetus to rubber planting in new areas, the work that has been done becomes of wider and greater interest. Dr. Dijkman has compiled an exhaustive review of research findings, drawn from inaccessible and foreign sources.

Soils and Soil Fertility. By L. M. Thompson. (McGraw-Hill Book Co., New York, London, 1952, ppp. xii + 339).

An introductory textbook on soil science for use in universities. The material is relevant primarily to the soils of the Mid-Western United States and the book is primarily appropriate for students in that region.

An Introduction to Agricultural Chemistry. By N. M. Comber, J. S. Willcox and W. N. Townsend (Edward Arnold, London, 2nd Edition 1952, pp. vii + 348, 18s. English).

This book combines the chemistry of soils (114 pp.), fertilizers (52 pp.) and animal nutrition (172 pp.), the last section including a solid introduction to the biochemistry of animal metabolism. The book is new and up-to-date and attractively written and produced. It is of introductory university standard, implying a previous knowledge of first-year chemistry. Universities differ widely, however, in their interpretation of the term "Agricultural Chemistry," and in most agricultural courses biochemistry is separated from soils. On this account the book is not likely to become as widely used as the inorganic or the organic section deserves on its own account.

Soil Blocks. John Innes Leaflet No. 12. (Oliver and Boyd Ltd., for the John Innes Horticultural Institution, 1953, pp. 7, 9d).

A summary of the preparation and use of soil blocks in place of clay pots in horticulture.

Fodder Beet. A Review. By P. J. Boyle. (Commonwealth Bureau of Pastures and Field Crops, Mimeo. Publication No. 1/1952, pp. 79, 5s. English).

A review, with bibliography, of the origins of fodder beet, its varieties, cultivation, harvesting and use as fodder. The materal reviewed and its application are primarily European.

M.I.A. Fruit Trees and Grape Vine Census. Revision, December, 1951. (Publ. by Irrigation Research Extension Committee, Murrumbidgee Irrigation Areas, N.S.W., 1952, pp. 43).

Revised lists of plantings in the M.I.A., to be regarded as supplementary to earlier reports.

A Comparative Survey of Economic Conditions in two Pastoral Areas of South Australia, with particular reference to the Provision of Credit. By A. P. Bailey (Bureau of Agricultural Economics, Candedda, 1952, pp. 70).

Surveys of developments in farm debt structure in two sheep-farming areas, carried out at the University of Adelaide. They illustrate a contrast between the higher rainfall areas of the South-East and the drier Mid-North marginal areas, in the financial status of farms and the changes in indebtedness and tenure that have taken place since the areas were opened to settlement.

Selection for Economic Characters in Australian Merino Sheep. (1) Estimates of Phenotypic and Genetic Parameters. By F. H. W. Morley (N.S.W. Department of Agricultural Science Bulletin No. 73, 1951, pp. 45).

This is one of a series of papers. It presents a quantitative analysis of the economic characters in an Australian Merino flock, and their interrelationships. The conclusion is reached that improvement is limited more by negative genetic correlations between various characters than by low genetic variability or low heritability of individual characters.

List of Sugar-Cane Insects. By H. E. Box (Commowealth Institute of Entomology, London, 1953, pp. 101, 15s. (English).

A catalogue of the sugar-cane insects and mites of the world, and of their insect parasites and predators, arranged systematically.

ERRATUM

Volume 19, No. 2, June, 1953

In the Membership Roll, Victorian Branch, line 44, column 1, page 136, should be altered to read JOHNSTON, H. D., B.Ag.Sc.—Production Manager, Associated Dairies Ltd., 1438 High Street, Glen Iris.

PUBLIC SERVICE OF SOUTH AUSTRALIA.

Applications for the undermentioned positions will be received by the Public Service Commissioner, 31 Flinders Street, Adelaide, until and including 10th October, 1953.

Applicants should state full name, date of birth, address, marital status, academic qualifications, practical experience and particulars of war service (if any). Copies only of testimonials should be submitted.

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